AMERICAN JOURNAL OF ORTHODONTICS

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TABLE OF CONTENTS ON PAGE 2

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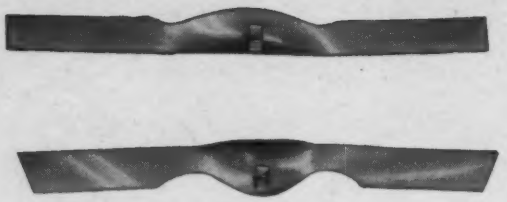
Vol. 44 **MARCH, 1958** **No. 3**

developed especially for the "EDGEWISE TECHNIC"



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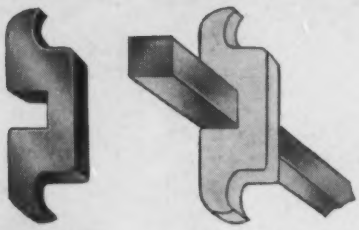

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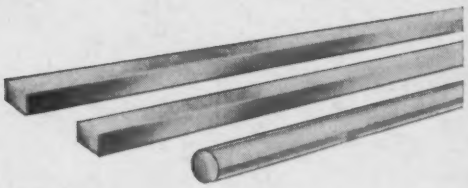

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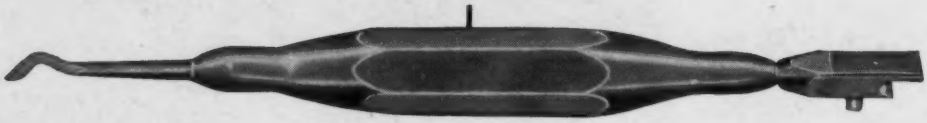

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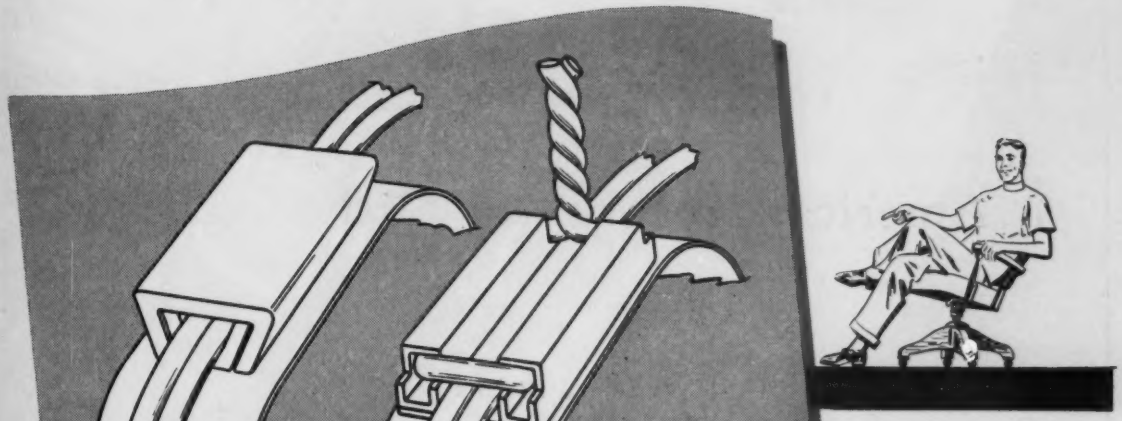

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CONTENTS FOR MARCH, 1958

American Journal of Orthodontics

Original Articles

Cephalometric Roentgenography of Infants: Sedation, Instrumentation, and Research. Samuel Pruzansky, D.D.S., and Edward F. Lis, M.D., Chicago, Ill. ---- 159

A Cephalometric and Histologic Study of the Effect of Orthodontic Expansion of the Midpalatal Suture of the Cat. Edgard F. Debbane, D.C.D., M.S., Rochester, N. Y. ---- 187

The Responsibilities of the Dental Specialties. William Alstadt, D.D.S., Little Rock, Ark. ---- 220

Editorial

Doubt and Certainty in Roentgenographic Cephalometrics ---- 224

In Memoriam

Joseph O. Baker ---- 227

Asa J. La Grow ---- 227

Arthur Bartlett Thompson ---- 228

Department of Orthodontic Abstracts and Reviews

Orthodontic Abstracts and Reviews ---- 230

News and Notes

News and Notes ---- 232

Officers of Orthodontic Societies

Officers of Orthodontic Societies ---- 242

(Editorial and Business Communications on inside back cover)

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The Management of ORAL DISEASE

A Treatise on the Recognition, Identification, and Treatment of Diseases of the Oral Regions

by

JOSEPH L. BERNIER, D.D.S., M.S., F.D.S., R.C.S. (Eng.) Colonel, Dental Corps, United States Army; Chief, Oral Pathology Branch, Armed Forces Institute of Pathology; Pathologist to the Registry of Oral Pathology of the American Dental Association; Professor of Oral Pathology, Georgetown University of Dentistry.

1955, 825 pages, 6¾" x 9¾", 1001 illustrations,
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- To present newer concepts relating to the role of stress, and the influence of general disease on oral disturbances.
- To clarify many unnecessarily complicated concepts regarding oral disease, by presenting explanations couched in simple language.
- To establish the relation between oral pathology and the clinical specialties of dentistry.
- To illustrate the role of oral pathology as it exists today in the teaching and practice of dentistry, as well as in general pathology.

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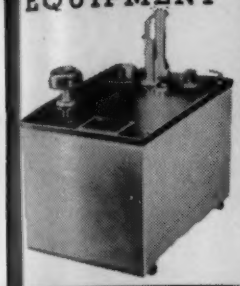

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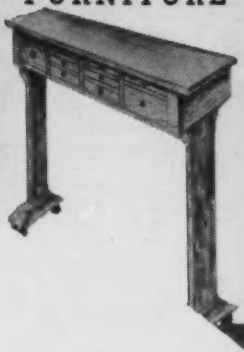

OPERATING AIDS

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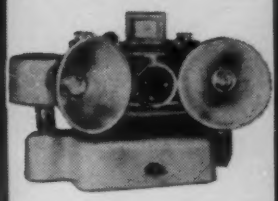

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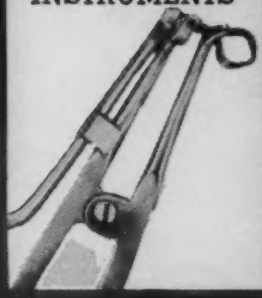

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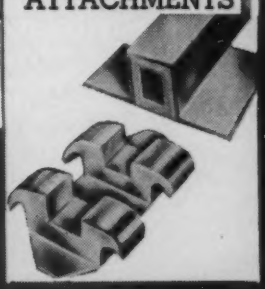

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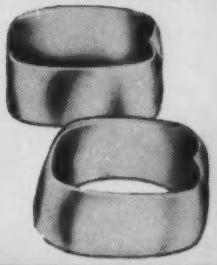

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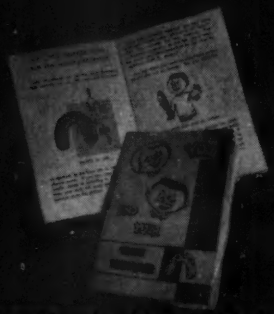

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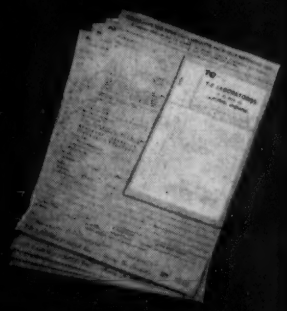

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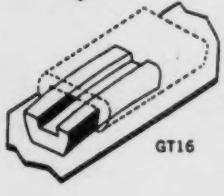
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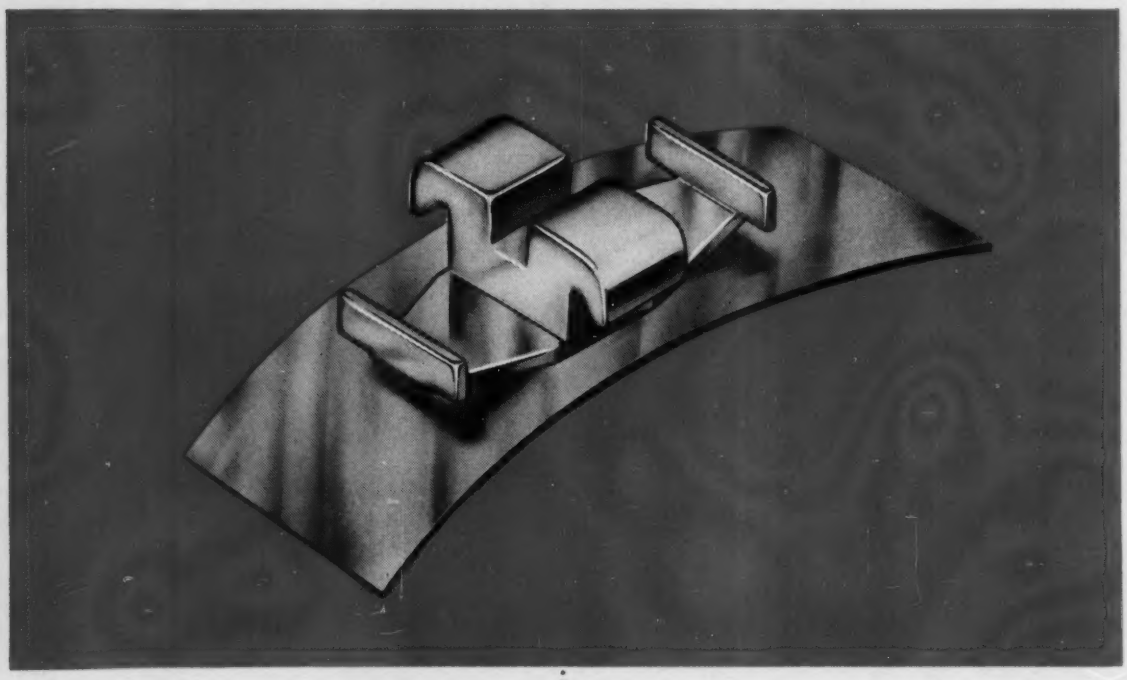

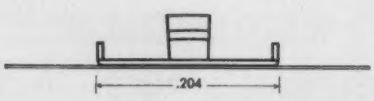

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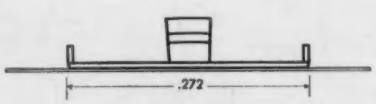
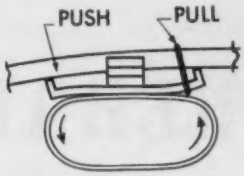
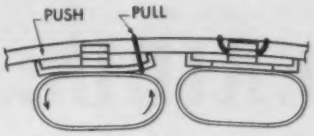


long–UT 650



Push-pull bracket uses double leverage to rotate tooth



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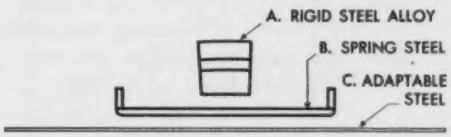

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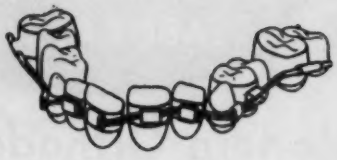

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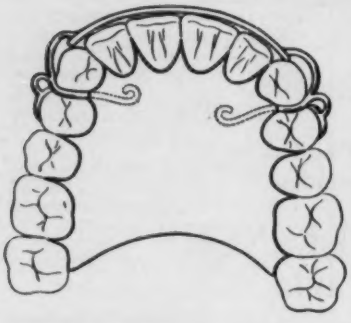

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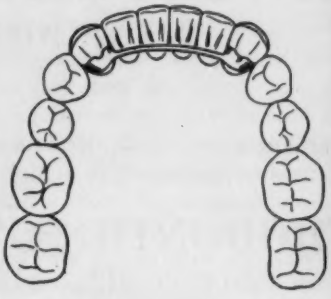

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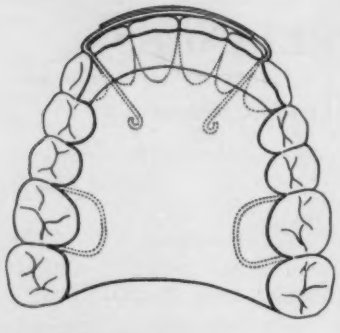

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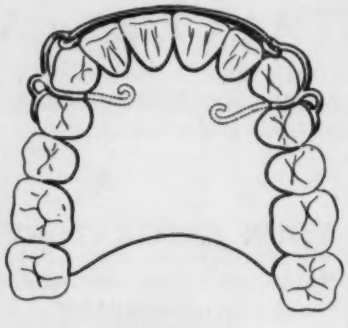

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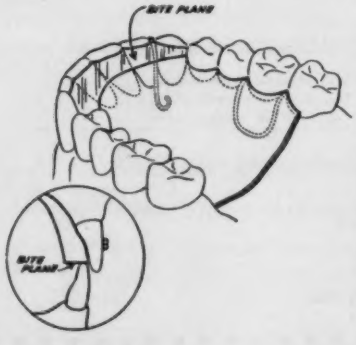

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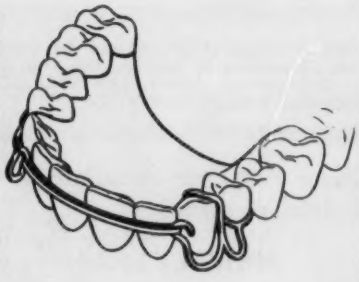

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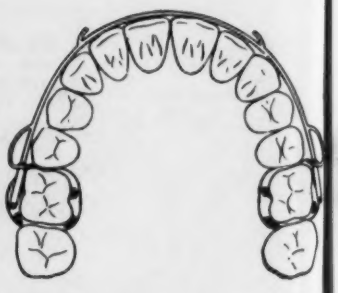

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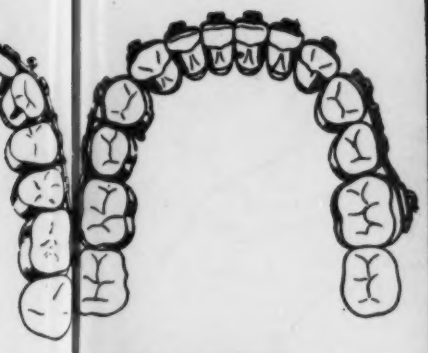

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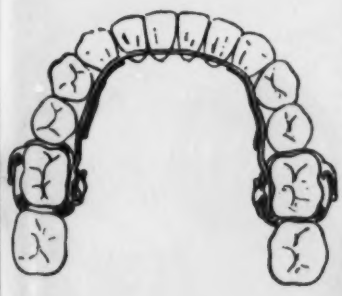

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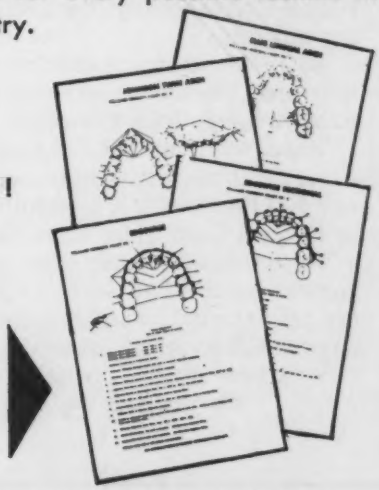

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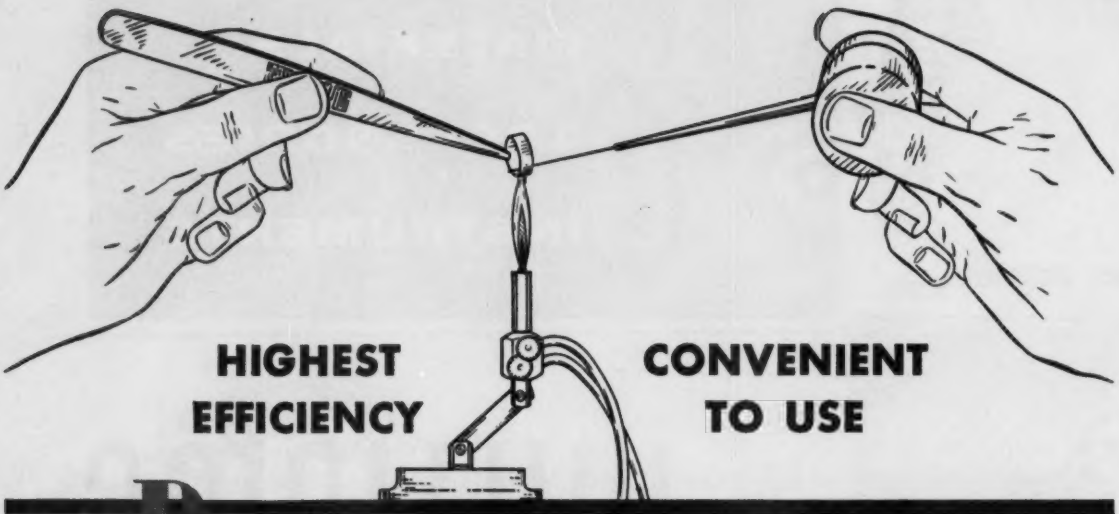

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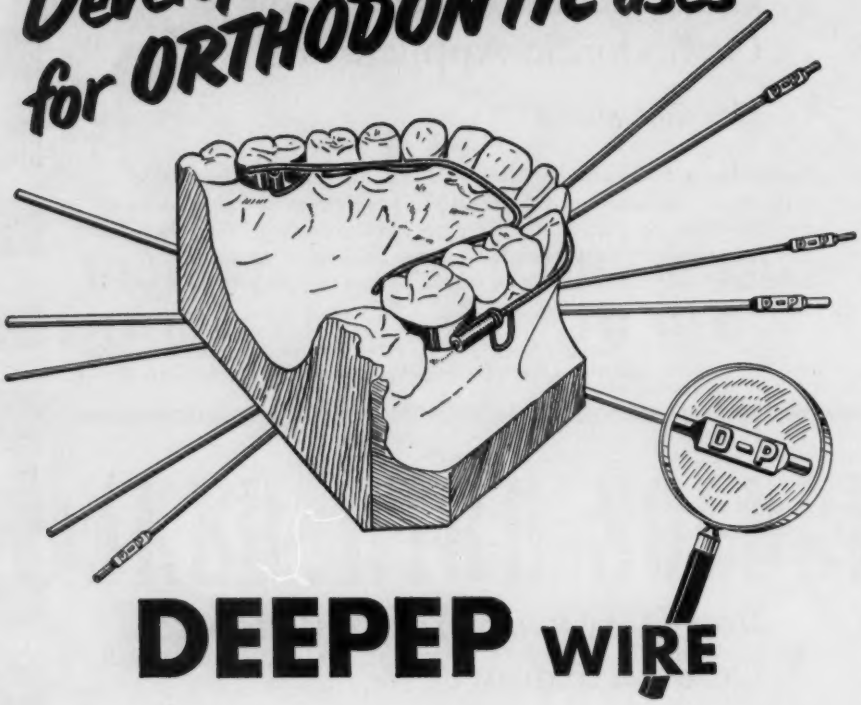

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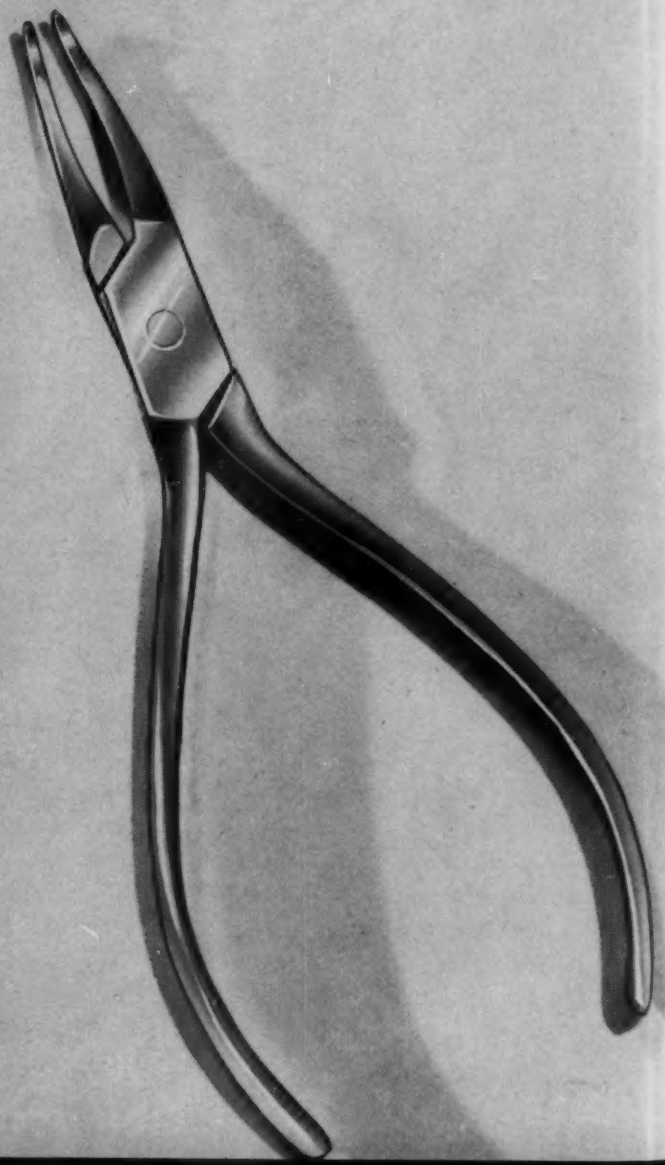

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Original Articles

CEPHALOMETRIC ROENTGENOGRAPHY OF INFANTS: SEDATION, INSTRUMENTATION, AND RESEARCH*

SAMUEL PRUZANSKY, D.D.S., AND EDWARD F. LIS, M.D., CHICAGO, ILL.

INTRODUCTION

IT IS a well-established fact that the greatest increments in postnatal growth of the head in man occur during the first year of life.[1] Despite the increasing interest in cephalometric roentgenology as a means of measuring growth of the head, comparatively little information has emerged regarding the patterns of normal and abnormal growth of the face and cranium during this period of most prolific growth.

Previous attempts to obtain cephalometric films of infants were largely unsuccessful as the infants could not be accurately positioned within the head-holding device and maintained without movement for the duration of the exposure. Reducing the exposure time to a fraction of a second offered no solution, for there could be no certainty that the unwilling subject would be properly related to the head holder or that there would be constancy of posture of the head or of the mandible during the instant of exposure. In one instance the head might be in extension with the jaws wide open, and in another the head would be in ventroflexion with the jaws tightly shut. To complicate matters further, conventional cephalometric equipment was not readily adaptable to the positioning of small children.

From Center for Handicapped Children, Cleft Palate Clinic, The Chicago Professional Colleges, University of Illinois.

*Awarded first prize in the 1957 annual Prize Essay Contest of the American Association of Orthodontists.

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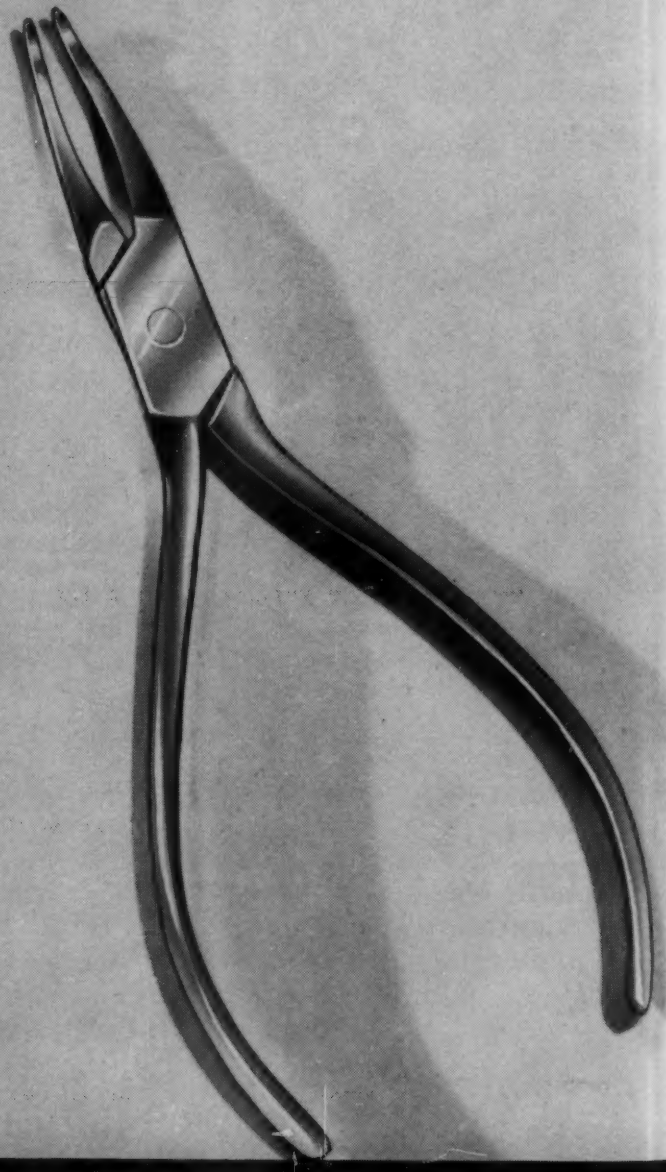

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Apparently, two problems had to be solved in order to make cephalometric roentgenography of infants and young children feasible. First and foremost, it was necessary that a safe and simple method be devised for quieting small children for a period of short duration. The second problem involved the adaptation of the general principles of the Broadbent-Bolton cephalometer[2] to the design of an instrument specifically suited to the handling of infants.

This report is concerned with the experience gained in sedating infants and with the description of a cephalometer designed for this special purpose. Examples of various problems under investigation were selected to illustrate the usefulness of these methods and their potential contribution to the sum of knowledge on the growth and development of the head in man.

SEDATION

Goodman and Gilman[3] offer the following definitions of hypnosis and sedation:

> In the pharmacological sense, hypnosis is a condition of sleep produced by hypnotic drugs. Sedation is a milder state of central depression in which the patient, although awake, has a lessened degree of cortical excitability and is, therefore, more calm and tranquil.

It appears that where barbiturates are employed the distinction between hypnotic and sedative is merely a difference of dosage. For obvious reasons, the term *hypnotic* is not always desired in clinical practice and the word *sedative* is preferred. Therefore, in this article we shall adhere to common usage and employ the terms *sedative* and *sedation* to signify the utilization of a drug for purposes of inducing a mild degree of narcosis.

The present experience is derived from a longitudinal growth study of a large series of infants with cleft lip and palate or other congenital anomalies of the head and a smaller series of normal infants. Since 1949 about 4,000 sedations have been carried out on nearly 500 different children for the purpose of cephalometric roentgenography.

Indications for Sedation.—The normal reactivity of the infant and the small child precludes the wakeful state in performing precise roentgenographic examinations which require dependable immobility. It is a routine practice in many x-ray laboratories either to sedate such patients or to take multiple exposures to insure an adequate result. In the absence of contraindications, sedation is often the procedure of choice.

The sedative for infants and small children which has been used with good results in our experience is secobarbital, a short-acting barbiturate. Breslow and Poncher[4] have previously described the efficacy of this barbiturate in pediatric procedures. The rapid onset and the relatively short duration of the sedative facilitates its use in both hospital and outpatient procedures. Secobarbital sedation has been employed in the nonpainful examination of the eyes, ears, nose, and pharynx and in the palpation of abdominal masses. Similar sedation is often necessary in obtaining electroencephalograms of infants and small children.

Pharmacodynamics.—For a detailed review of the pharmacologic action of barbiturates in general and secobarbital in particular, the reader is best referred to the standard texts on pharmacology. Certain characteristic actions of the barbiturates, however, are pertinent to our consideration of sedation in the small child and merit repetition.

In common with other barbiturates, secobarbital acts as a depressant of the cerebrospinal axis. The intensity of this depressant effect on the central nervous system depends not only upon the particular dose and route of administration, but also in large measure upon the level of reflex excitability of the patient's nervous system at the time the drug is administered.

The narcosis induced by secobarbital sedation resembles physiologic sleep. As in sleep, there is a decrease in respiratory exchange and muscular activity is lessened. Larger doses of the sedative, however, are directly depressant to the medullary respiratory center and, to a lesser degree, to the sino-aortic chemoreceptors.[3]

An added advantage to secobarbital sedation is that it produces postsedation amnesia for the events that transpired during the examination. This is an important consideration in minimizing the psychic trauma and fear engendered in the small child.

Secobarbital, in the dosage employed herein, will not produce effective sedation when pain is a predominating symptom or maintain its effect if pain is produced in the course of an examination.

Presedation Care.—Certain precautions should be followed carefully in the preparation of the patient for sedation. If oral examinations or dental impressions are contemplated, it is advised that milk and other food be withheld for at least four hours prior to any intraoral procedure to avoid vomiting.

In our clinic, where oral examinations were concurrent with cephalometric procedures during sedation, the following letter was sent to the parents for their instruction:

> Please do not feed the child milk or other food substances for four hours immediately preceding the appointment hour. Bring the usual milk formula and such additional nourishment as the child takes, as well as a nursing bottle of water for children under two years of age. Adequate provisions for the transportation of a sleeping child should be made. If possible, bring a relative or friend to assist in the management of the child and provide a blanket for covering the child.
>
> If the child has a cold, an elevation in temperature, diarrhea, vomiting, pronounced cough, or any illness on the scheduled day, feel free to request another appointment at a later day in order to save yourself an unnecessary trip to the clinic.

If the infant was very hungry, sedation could not be readily achieved. For this reason, a nursing bottle of water might serve to minimize the pangs of hunger and facilitate sedation. In hot weather, the feeding of water at an appropriate time after the procedures were completed also prevented dehydration.

Upon arrival at the clinic, the child's weight and rectal temperature were obtained by a nurse. If the child had been sedated on previous occasions, the

mother was questioned about the patient's past reactions to sedation. Intraoral and pharyngeal areas were examined to determine the presence of foreign bodies. It was of primary importance to determine whether the child had any difficulty in breathing, either in the wakeful state or when asleep. Where doubt existed as to the child's suitability for sedation, the patient was referred to the staff pediatrician for consultation.

Method of Administration.—Secobarbital in its various physical forms may be administered by the parenteral, oral, or rectal routes. Obviously, the use of parenteral injections is objectionable to parents and child alike, especially if repeated procedures are contemplated. The oral method is unreliable for the protesting child. Thus, by exclusion, the rectal route has been applied in the pediatric setting of this clinic as well as elsewhere. Rectal administration has the added advantage of a greater margin of safety in dosage and elimination of unabsorbed drug, if circumstances so indicate. The drug is readily absorbed from the rectum, especially if the rectal ampulla is empty.

Various pharmacologic preparations of secobarbital can be used for rectal administration: the gelatin capsule of secobarbital powder, an aqueous suspension of this powder removed from the capsule, or the sodium salt of secobarbital in aqueous solution or in a suppository base. The capsule and suppository forms are somewhat more convenient, but they are less dependable in terms of rapidity and reliability of absorption, especially in the presence of stool in the rectum. For these reasons, the aqueous suspension or solution has been our method of choice for rapid induction and minimal dosage.

The technique of administration was as follows: The secobarbital powder was suspended in 5 to 8 c.c. of water and given as a retention enema. A 10 c.c. syringe with a 3 inch flexible tube, lightly lubricated, was sufficient to administer the drug. A smaller amount of water was used to flush the tubing and insure the administration of the full dosage. The approximated buttocks were taped with adhesive to prevent accidental loss of the medication in a straining child.

The child was then carried to a quiet, nonstimulating, preferably darkened area and held in the arms of his parent. Usually a period of twenty to thirty minutes elapsed before a sleeping state was produced and the child was ready for the cephalometric procedure. During this time, the child was wrapped in a blanket to maintain warmth in the sleeping state.

Postsedation Instructions.—Specific postsedation instructions were given to the parents to assist them in dealing with a child in a sleeping state which might last from two to eight hours. During this time, some children reacted in an irritable and uncooperative fashion resembling the behavior of an adult inebriate. This state was often precluded by avoiding all extraneous stimulation of the sleeping child and allowing him to awaken when ready. If the child awoke prematurely, he remained drowsy or irritable and required protection from all potential accidents through close observation by his parents. The hyperirritable child preferably was held in the parent's arms or placed

in a crib. Occasionally it was necessary to keep a sedated child under observation for a few hours if it appeared that the sedative action was too deep or if the parents could not be relied upon to follow instructions for safeguarding the child.

Initial feeding following awakening consisted of water. If no vomiting ensued, small amounts of tea or broth and finally milk or solids were given as the child manifested complete emergence from the sedation.

Contraindications.—There are certain absolute and relative contraindications to sedation of infants for elective procedures. As a guiding principle, any pathology which involves vital organs of the body and is associated with a lowered functional reserve is an absolute contraindication. Special consideration before sedation is necessary for infants with disturbances of the central nervous, respiratory, cardiac, hepatic, and endocrine systems and for infants who are malnourished, chronically or acutely ill, or generally under par. Brain damage may involve the respiratory center or affect the muscles controlling deglutition, respiration, and muscular tonus and thus presents a hazard. Respiratory function may be threatened by congenital or acquired obstructions, such as mandibular micrognathia with glossoptosis, macroglossia, nasal atresias, and pathology of the lower respiratory tract. Stridor, difficult or abnormal breathing, cyanotic episodes, and retraction of the supraclavicular, suprasternal, intracostal, or subcostal areas are ominous symptoms forewarning caution in sedation. Hepatic dysfunction or immaturity may be associated with a slower rate of detoxification and thus may prolong or intensify the sedation.

The common upper respiratory tract infection may seem innocuous. However, in the state of induced sleep the infant may not be able to cope with the increased mucous exudate in the respiratory passages. Airway obstruction by this exudate may occur during the state of reduced reflex activity accompanying sedation.

The double hazards of obstruction and respiratory depression are increased when alginate impressions are taken of the oral cavity during sedation. It is best to allow the infant to begin to emerge from sedation before such procedures are undertaken.

If all the precautions are understood and carefully observed, medically supervised barbiturate-induced sleep is a relatively safe procedure. Optimum safeguards are insured by having a physician skilled in child care in attendance during the selection of patients and for such parent counselling as is required. A registered nurse is an asset in the preparation of the child and in the guidance of the parents.

These are the essential prerequisites for cephalometric roentgenography of infants. The precautions noted are required to maintain the highest safety standards essential for any elective procedure. Any facility providing less than the highest standard should not be countenanced.

INSTRUMENTATION

The Cephalometer.—The prototype of the present cephalometer for infants was described by Ortiz and Brodie.[5] Their instrument was of the same basic

design as the Broadbent-Bolton cephalometer, except that it was built around a table instead of a dental chair and only one tube (the lateral) was employed.

The current model represents an improvement on the mechanical design of the original and includes certain additional features. Like the original, the top of the table in the new design consists of a head-holding device in fixed relation to the x-ray tube. The part upon which the infant is placed in a supine position can be raised or lowered and moved caudad or cephalad. The fixed portion of the table carries a cassette holder which can be racked medially or laterally, moved caudad or cephalad, or adjusted in the vertical direction to accommodate variations in head size (Figs. 1, 2, and 3).

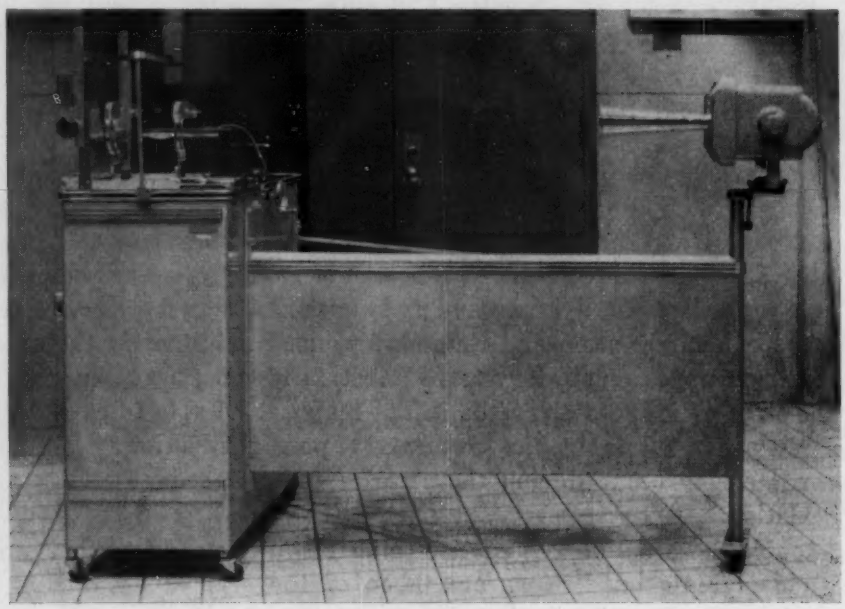

Fig. 1.—The cephalometer for infants.

In the present design, a gear-and-rack arrangement provides for simultaneous movement of the right and left ear posts. A separate holder permits the positioning of a leaded aluminum millimeter scale at the midsagittal plane. A marker on this scale is placed in line with the porionic axis. The ear rods, together with the marker on the leaded scale in the midsagittal plane, provide guides for the orientation of the head in the Frankfort horizontal plane.

The ear posts and their supporting arms were fabricated of rigid but relatively radiolucent plastic materials. This allows for the visualization of anatomic landmarks heretofore obscured by the large metallic supports on other head-holding apparatus.

The lateral x-ray tube was mounted on an extension of the table. The mechanical fixation of the tube facilitates its careful positioning vertically and horizontally. The distance from the anode to the midsagittal plane is 5 feet, the same as in the Broadbent-Bolton cephalometer.

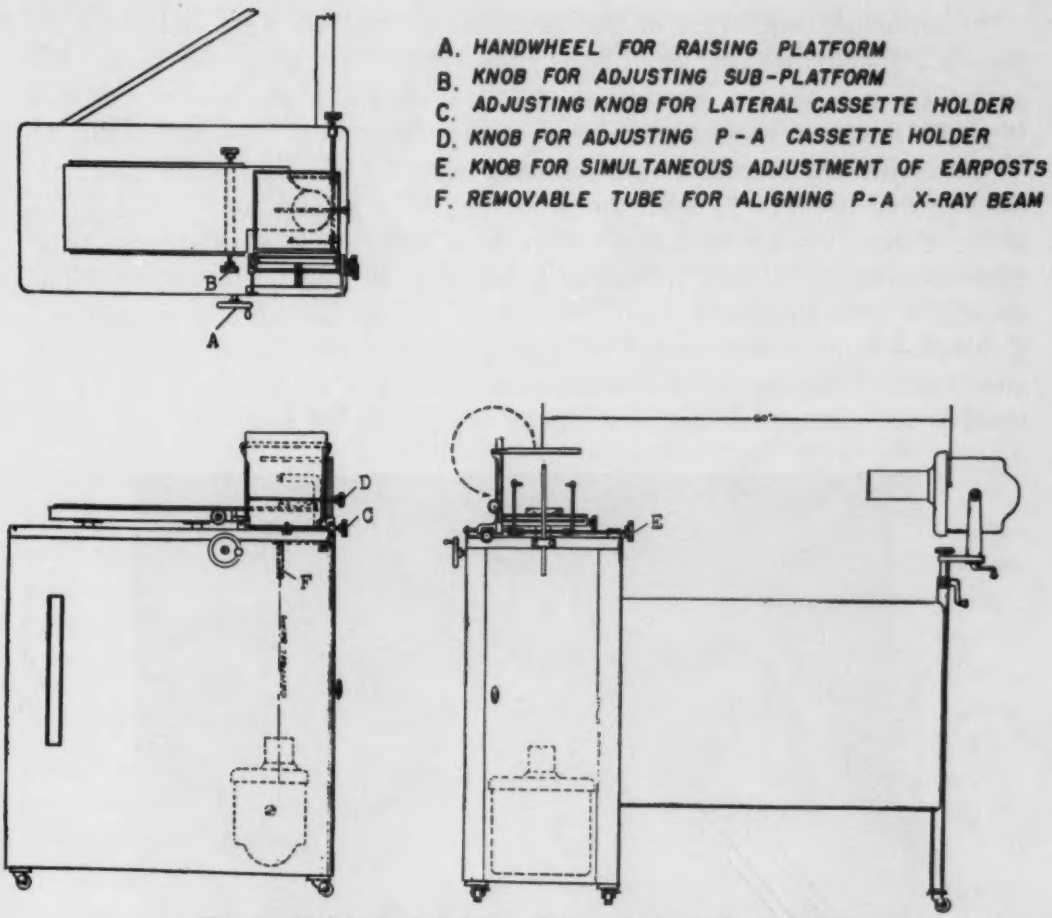

Fig. 2.—Skeletonized sketches of the cephalometric equipment.

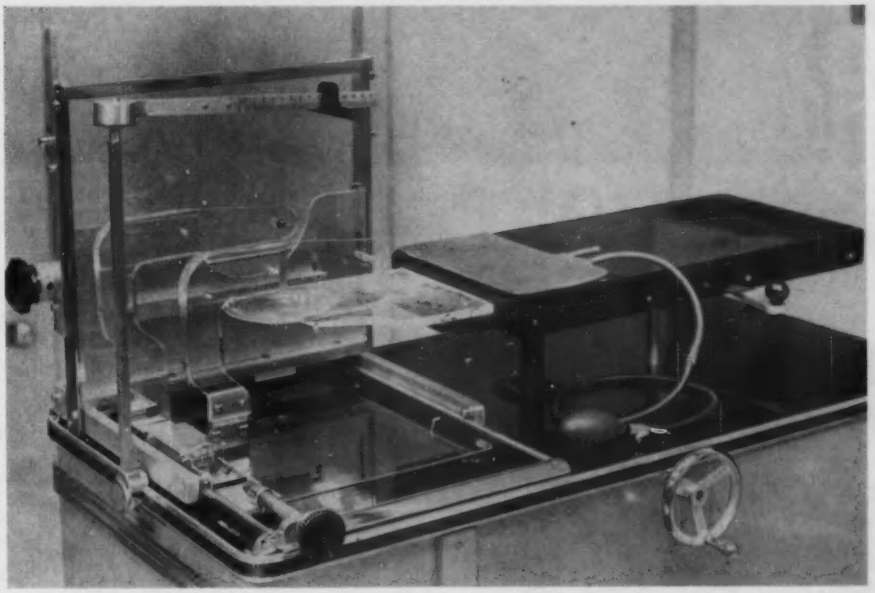

Fig. 3.—Close-up view of head holder. Sphygmomanometer cuff may be inflated beneath infant's shoulders to facilitate alignment of head, neck, and shoulders.

Continuous monitoring of the alignment of the ear posts and the x-ray tube is available by fixing small brass rings around each of the ear posts. The concentricity of the two brass rings and the casting of a perfect circle on each processed film assure a continuous check on the alignment of these parts (Fig. 4).

To provide a frontal film, a second x-ray tube was mounted beneath the head-holding device. To avoid the construction of a large and unwieldy machine, it was necessary to mount the anode of this tube at a distance of 3 feet from the transmeatal axis, instead of 5 feet as prescribed by Broadbent-Bolton standards. The alignment of this tube can be checked periodically by placing a 6 inch hollow brass tube in the midsagittal plane perpendicular to the transmeatal axis. The hollow tube is mounted inside the machine and can be rotated to one side, out of line of the x-ray tube, when not in use (Fig. 2).

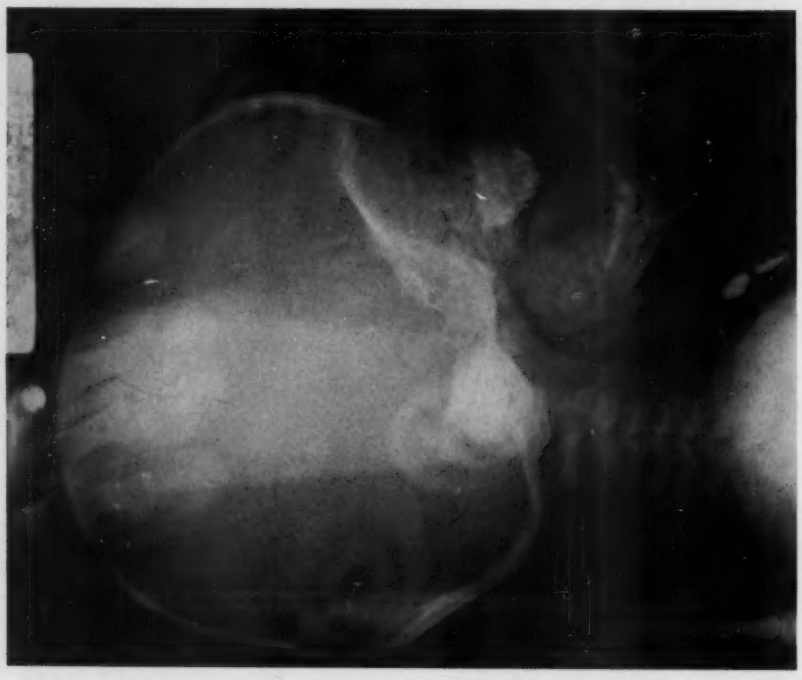

Fig. 4.—Lateral x-ray picture of infant with correctional scale in midsagittal plane.

Positioning the Infant.—Prior to placing the sedated infant on the table, the child's clothing is adjusted to remove buttons, zippers, and pins from the neck region, lest these appear on the film and obscure areas of interest. A minimum of clothing should be worn to reduce the bulk in the left shoulder area. This is done to keep the film-object distance at a minimum.

The infant is placed supine on the table and the head is centered within the plastic cup. Since the occiput is generally asymmetrical, it is necessary that the parent's hands maintain the child's head in the desired position. The table is then adjusted up or down, forward or backward, until the ear posts are in line with the external acoustic meati. The knob regulating the movement of the vertical supports of the ear posts is then adjusted to place the

ear posts within the meati. The infant's head is finally adjusted in the Frankfort horizontal position and maintained in that position by the hands of the parent standing at the head of the table.

Positioning of the infant in the supine position is complicated by variations in the length and shape of the occiput. Generally, when a patient is placed supine on a flat plane the prominence of the occiput is such as to produce a flexion of the head upon the chest. In dolichocephalic infants, this flexion is in the extreme. To facilitate positioning in the Frankfort horizontal plane, a concave depressed plastic cup was designed to allow the occiput to rest at a level lower than that of the plane of the table top. In addition, the shoulders were raised to assist in extension of the head. Excessive manipulation of the infant was avoided by placing a sphygmomanometer cuff beneath the shoulders and slowly inflating it until the proper postural alignment of head to neck to body was obtained within the head holder (Fig. 3).

Radiation Hazards.—The long-range effect of exposure to radiation warrants special attention in the light of increasing knowledge concerning the genetic results of cumulative doses. According to existing standards in medical practice, the radiation exposures incurred in these investigations were far below the limits of safety. Nevertheless, it is recognized that children with multiple anomalies or acquired ailments may be subjected to multiple x-ray analyses in several different hospitals or in many departments of the same institution. In such cases particularly, a history and diary of exposure to radiation must be maintained and elective roentgenographic studies should be minimized or eliminated.

Recommendations have been made to lessen the area of the body that must be exposed, the time that the patient is subjected to the x-ray beam, and the dosage output of roentgen-ray machines.[6] To provide and maintain the highest safety standards in our laboratory, equipment and procedures are periodically reviewed by a radiation physicist, attention is given to individual patient history, and laboratory personnel are equipped with radiation badges.

RESEARCH

Superpositioning of Lateral Film Tracings.—The use of small plastic ear rods and rigid supporting arms of radiolucent plastic permitted the clear visualization of anatomic landmarks previously concealed by bulky metallic head-holding devices. This made it possible to include in our tracings the sphenoccipital junction, basion, the mandibular condyles, and occasionally the outlines of the glenoid fossa. While it is not within the scope of this article to explore the philosophy or merits of various methods for superimpositioning of tracings, some observations seem pertinent to the design of the instrument.

In most attempts to seek a plane of reference, the cranial base was generally agreed upon as a stable area for superimpositioning. In our investigations, comparisons were made between several such techniques. When there was no change in the cranial base angle (nasion-sella-basion) or when there was a

desire to demonstrate changes in the cranial base angle, superimpositioning on the line sella-nasion with registration upon sella proved satisfactory. On the other hand, to average out changes in the cranial base, we used a modification of the Broadbent-Bolton orientation procedure in which basion was substituted for Bolton point (Fig. 5).

Improved design in apparatus allowed for the visualization of a number of anatomic landmarks heretofore obscured, thus permitting an evaluation of early growth changes in the cranial base area. This should prove of interest to cephalometric investigators concerned with correlating the growth of the cranial base with changes in the appended facial skeleton.

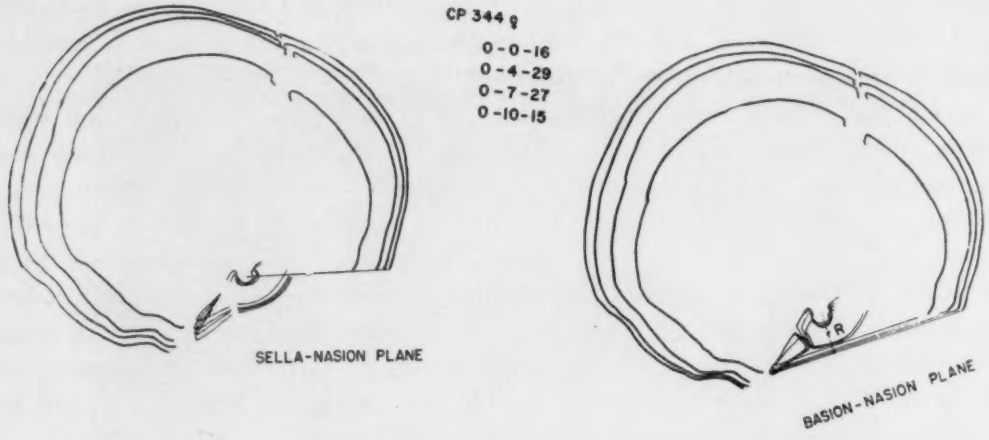

Fig. 5.—Comparison of two different methods for superimposing serial tracings.

Mandibular Posture in the Sedated State.—In reviewing the headplates of sedated infants, we were struck by what we regarded as a fundamental question: Was the rest position of the mandible, tongue, and hyoid bone observed in the sedated state similar to that which would exist if the infant had not been sedated? Of course, a direct answer could have been obtained by comparison with control headplates of the same infant obtained while in the nonsedated state. Since this was impossible, the answer to this question was derived indirectly.

The first clue that the postural relations of the mandible recorded in the roentgenograms of sedated infants were similar to those present in the nonsedated state came from cephalometric studies on the Pierre Robin syndrome.[7] The essential feature of this syndrome is a small mandible which fails to support the tongue in its proper forward position, consequently producing glossoptosis, respiratory obstruction, and related clinical symptoms.

In the infants exhibiting this syndrome the lateral cephalometric films provided a measurable estimate of the severity of airway obstruction. Indeed, the correlation between the degree of obstruction observed in the lateral roentgenogram and the severity of the clinical symptoms was so reliable that clinical

management in our clinic is now largely influenced by the cephalometric findings. Furthermore, as the cephalometric analysis revealed growth of the mandible sufficient to accommodate the tongue in a more forward position and increase the dimensions of the airway, there was a concomitant resolution of the clinical symptoms. The correlations between the x-ray findings, on the one hand, and the clinical course on the other, indicated that the postural relations of the mandible, tongue, and hyoid bone recorded in the sedated state must be similar to those existing in the unsedated infant.

Since the depth of sedation sometimes varied, there was some question as to how this variable might affect the regularity of mandibular posture. A review of serial series of films indicated that the posture of the mandible at rest in the sedated state, as measured by the parallelism of the lower border of the mandible, was remarkably regular for each infant, although it varied from infant to infant (Fig. 6). This finding was corroborated by Borden,[8] who

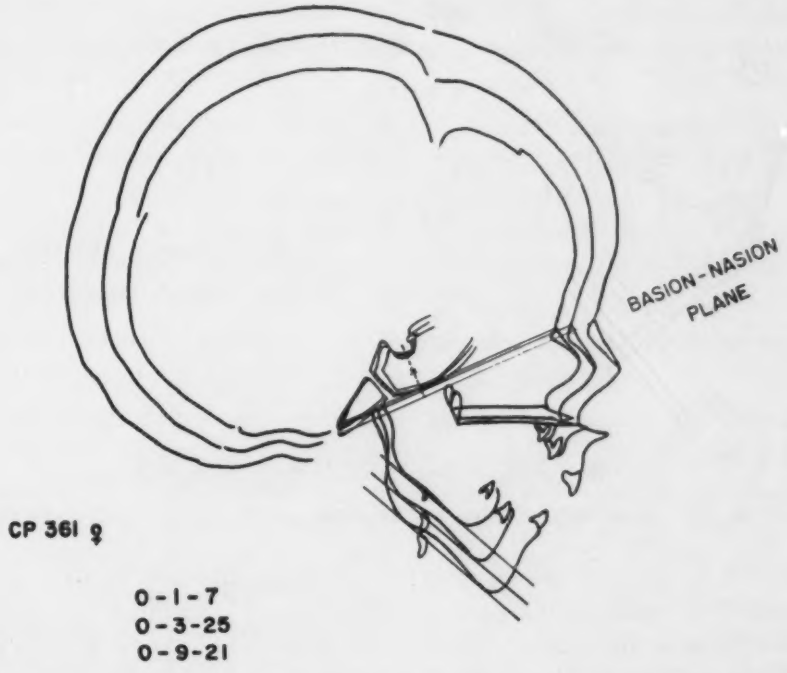

Fig. 6.—Serial tracings demonstrating regularity of rest position of the mandible in the sedated state.

analyzed a segment of our sample. It should be emphasized that such regularity of mandibular posture was obtained only when the posture of the head to the cervical column was constant. For these reasons, equal care must be taken not only to position the head within the Frankfort horizontal plane, but also to maintain proper postural relations betwen the head, the neck, and the body.

Comparison of the Sedated and Nonsedated States.—As many of the children in the longitudinal study grew older, it became possible to obtain similar

films in the supine position, utilizing the same cephalometric apparatus but without sedation. This made it possible to compare in the same child, but at different ages, the posture of the mandible at rest in the sedated and nonsedated states. It was found that mandibular posture, as measured by the parallelism of the mandibular plane, was no different in either state.

Comparison of the Supine and Upright Postures.—The oldest children in our longitudinal series have now matured sufficiently to permit cephalometric examination in the Broadbent-Bolton instrument. Since these recent examinations were obtained with the children sitting up, in contrast to the supine posture in the infant cephalometer, further comparisons of the mandibular rest position were made. It was found that rest position of the mandible was the same for a given child, regardless of whether the child was sedated or unsedated, supine or upright (Fig. 7).

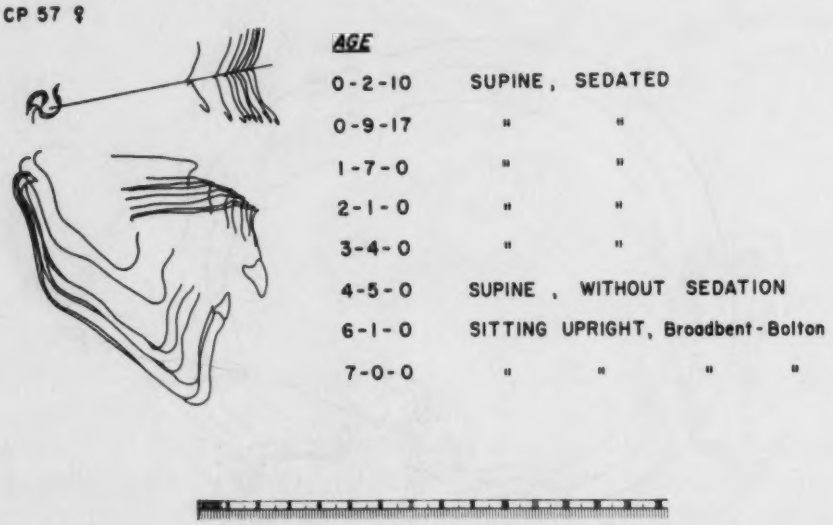

Fig. 7.—Rest position of the mandible in the same patient under varying circumstances.

Although a detailed documentation of these findings in this article was not intended, the problem of posture is sufficiently pertinent to cephalometric roentgenography of infants to warrant a summary of our results. (1) Rest position of the mandible in the sedated state is remarkably constant for a given infant; (2) this same posture obtains at a later age when similar examinations are performed without sedation; (3) similar rest positions of the mandible are recorded for the same child in the supine and upright postures; and (4) posture of the mandible is influenced by variations in the posture of the head as it relates to the cervical column and to the shoulders.

The Study of Congenital Anomalies.—So far, cephalometric studies of infants have been largely concerned with a wide variety of congenital deformities of the head. For the sake of outline, these will be divided into localized deformities of the neurocranium and facial bones and disturbances of general somatic growth. In making arbitrary divisions between the parts of the head,

it is understood, of course, that the skull is a community of bones. Although the several bones may have diverse phylogenetic origins and vary in their individual rates of growth, they are all bound together to give shape, size, and function to the community. When one part suffers in the course of growth and development, it seldom does so in isolation, for the community at large may also reflect, in one way or another, the misfortune of its member.

Congenital Defects of the Brain Case.—

1. *Craniosynostosis:* When one or more of the cranial sutures becomes obliterated, either before birth or shortly thereafter, deformity of the cranial vault ensues. Such deformities may become extremely grotesque, with involvement of the facial bones.

Of primary importance is the effect on the growth and function of the brain. During the first year of life, the brain increases about 135 per cent in weight, and during the same interval more than 50 per cent of all postnatal increase in the circumference of the skull occurs.[9, 10] If premature closure of cranial sutures is present at birth, significant restriction of the growth of the brain may follow.

Craniosynostosis or craniostenosis is the general term applied to this deformity, whose various types depend upon which sutures are involved. When one of the cranial sutures closes before the rapid growth of the brain is completed, an attempt at compensation results in overgrowth in whatever direction is still possible. Thus, if the sagittal sutures close permanently, lateral growth is limited and unusual anteroposterior expansion occurs, producing an extreme dolichocephalic skull. Conversely, if the coronal sutures close prematurely, lateral expansion produces extreme forms of brachycephaly.

A number of such cases were investigated by means of cephalometric roentgenography. It was demonstrated that, instead of the concentric tracings that characterize normal growth of the neurocranium, the growth increments were markedly eccentric. If craniectomy was performed in the first six months of life, not only was damage to the brain prevented, but nearly normal concentric patterns of cranial and facial growth followed (Figs. 8 and 9). Delay in craniectomy may lead to irreversible changes in the central nervous system and derangements in the architecture of the cranial base and the facial bones (Fig. 10).

The development of the facial deformities which characterize children with craniosynostosis has been documented in infants by means of cephalometric roentgenography. The facial deformities include shallow orbits and exophthalmos; deformation of the cranial base with reduction in the size of the airway, nasal atresia, and mouth breathing; arrested development of the jaws, lack of arch length, anterior openbite, and protrusive tongue. Since the severity of these deformities can be prevented or reduced by craniectomy in the first six months of life, it is anticipated that the results of these cephalometric investigations may contribute toward early neurosurgical intervention.

2. *Congenital absence of areas of the skull:* Such defects are usually small and occur in the parietal region. These defects decrease in size somewhat as growth proceeds but do not close completely.[11] The case reported here has been followed for a period of two years, since the patient was 4½ months old. During the period of roentgenographic observation, there has been a relative

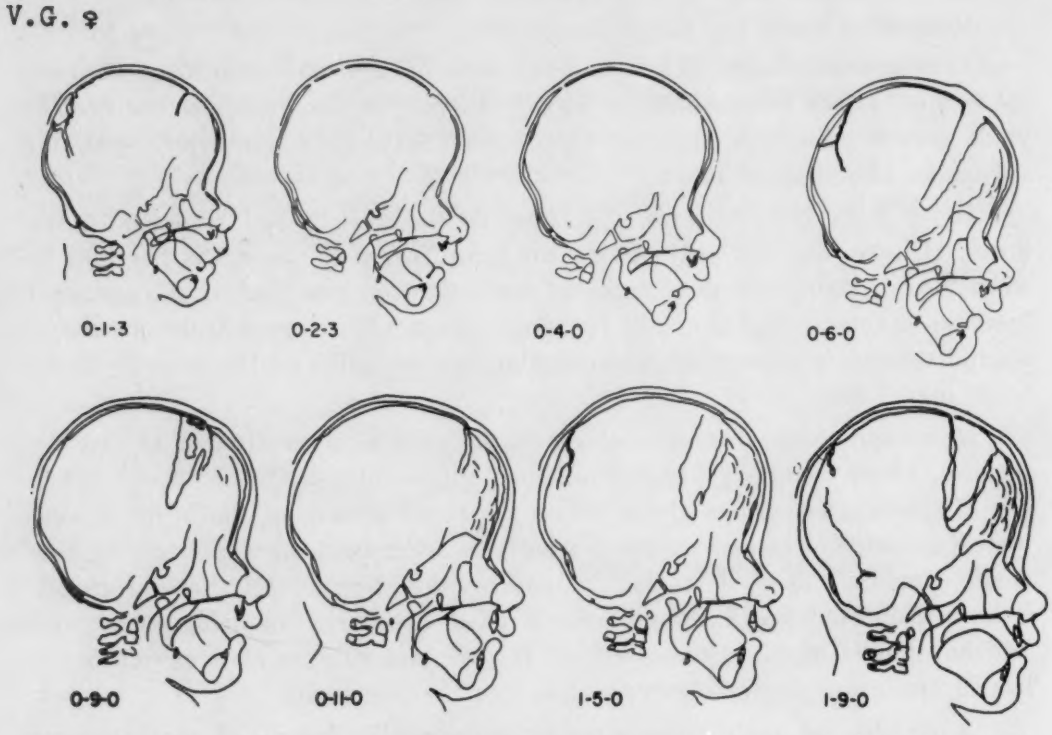

Fig. 8.—Craniosynostosis. Coronal craniectomy was first performed at 5 months and repeated at 20 months of age.

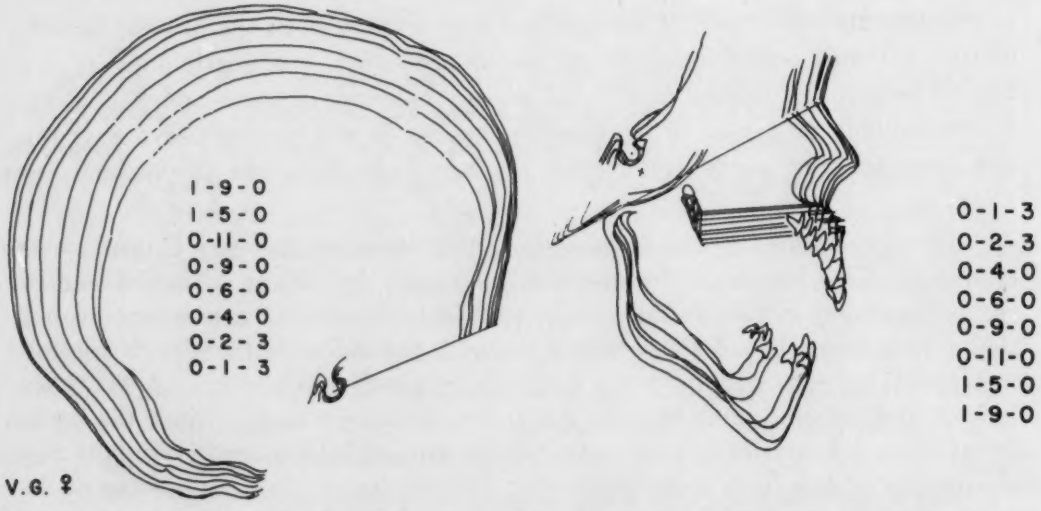

Fig. 9.—Serial tracings of brain case and face of patient in Fig. 8. (See text for discussion.)

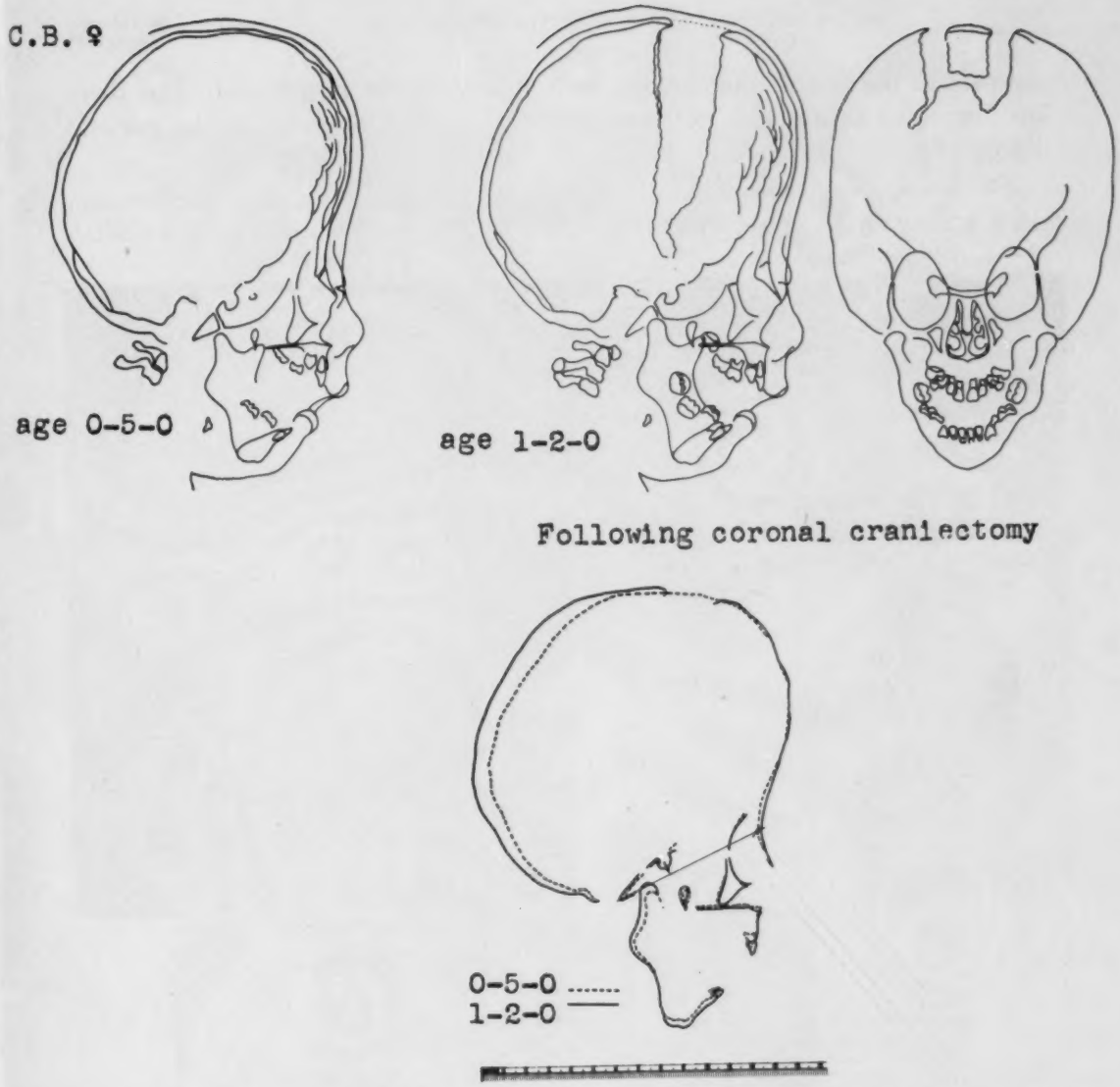

Fig. 10.—Craniosynostosis. Coronal craniectomy was performed after 1 year of age. Superimposed tracings reveal the abnormal pattern of craniofacial growth.

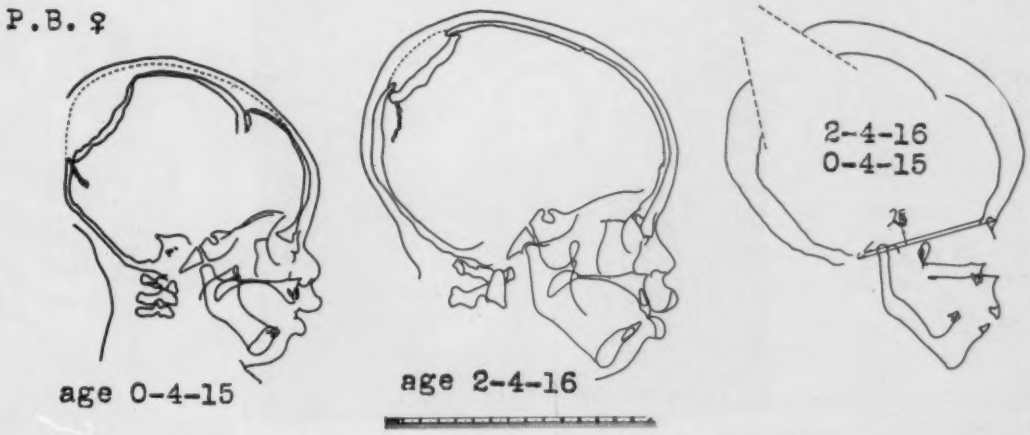

Fig. 11.—Congenital defect in the brain case. Note decrease in size of parietal defect with increasing age.

decrease in the size of the opening as it related to the larger skull, and there has been also an absolute decrease in the original dimensions of the parietal defect (Fig. 11).

3. *Nasal encephalocele:* This congenital anomaly is a form of cranium bifidum, and in the case illustrated in Fig. 12 it is associated with a median

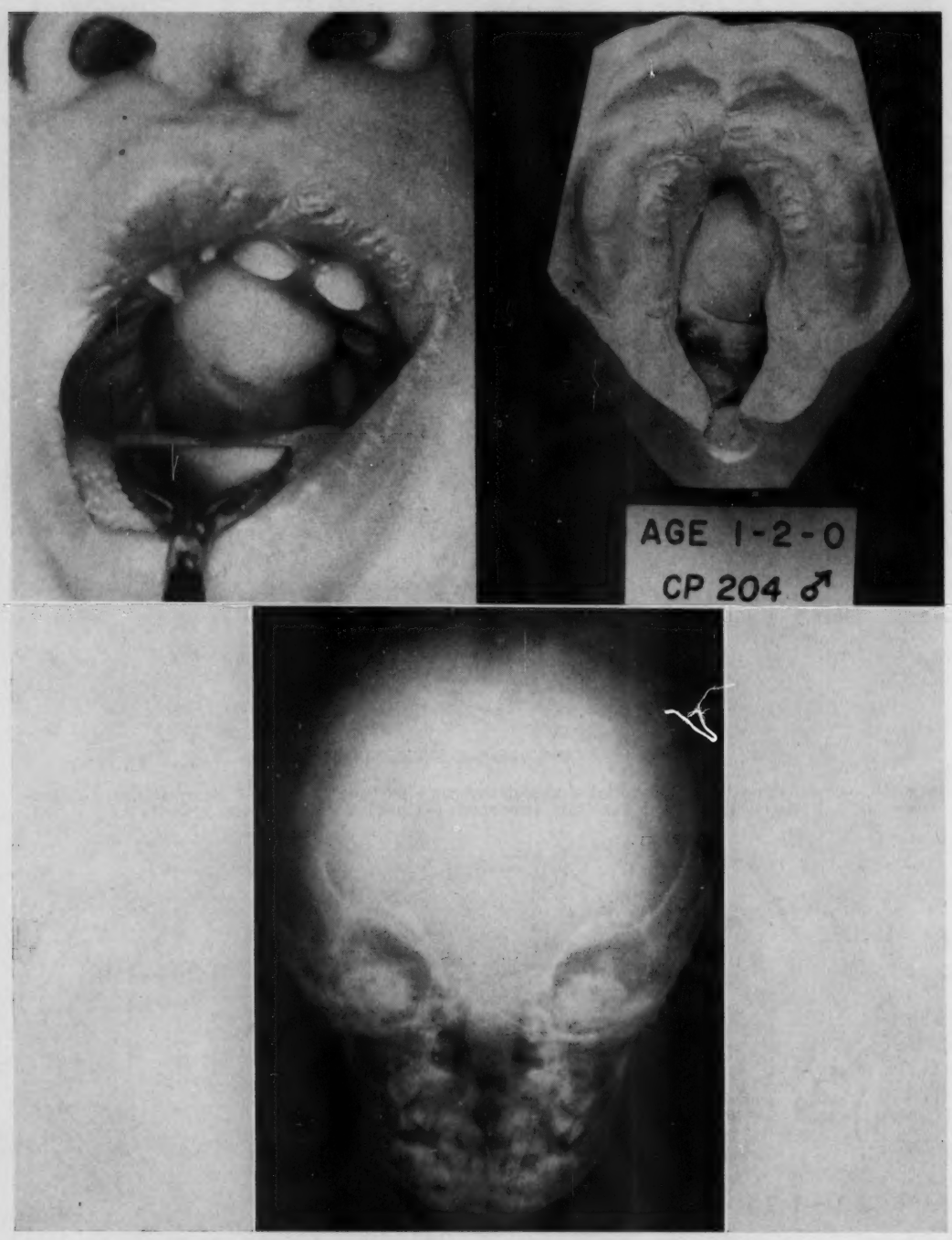

Fig. 12.—Nasal encephalocele. Pulsating mass extended downward from the cleft in the anterior cranial base through the cleft in the hard and soft palate.

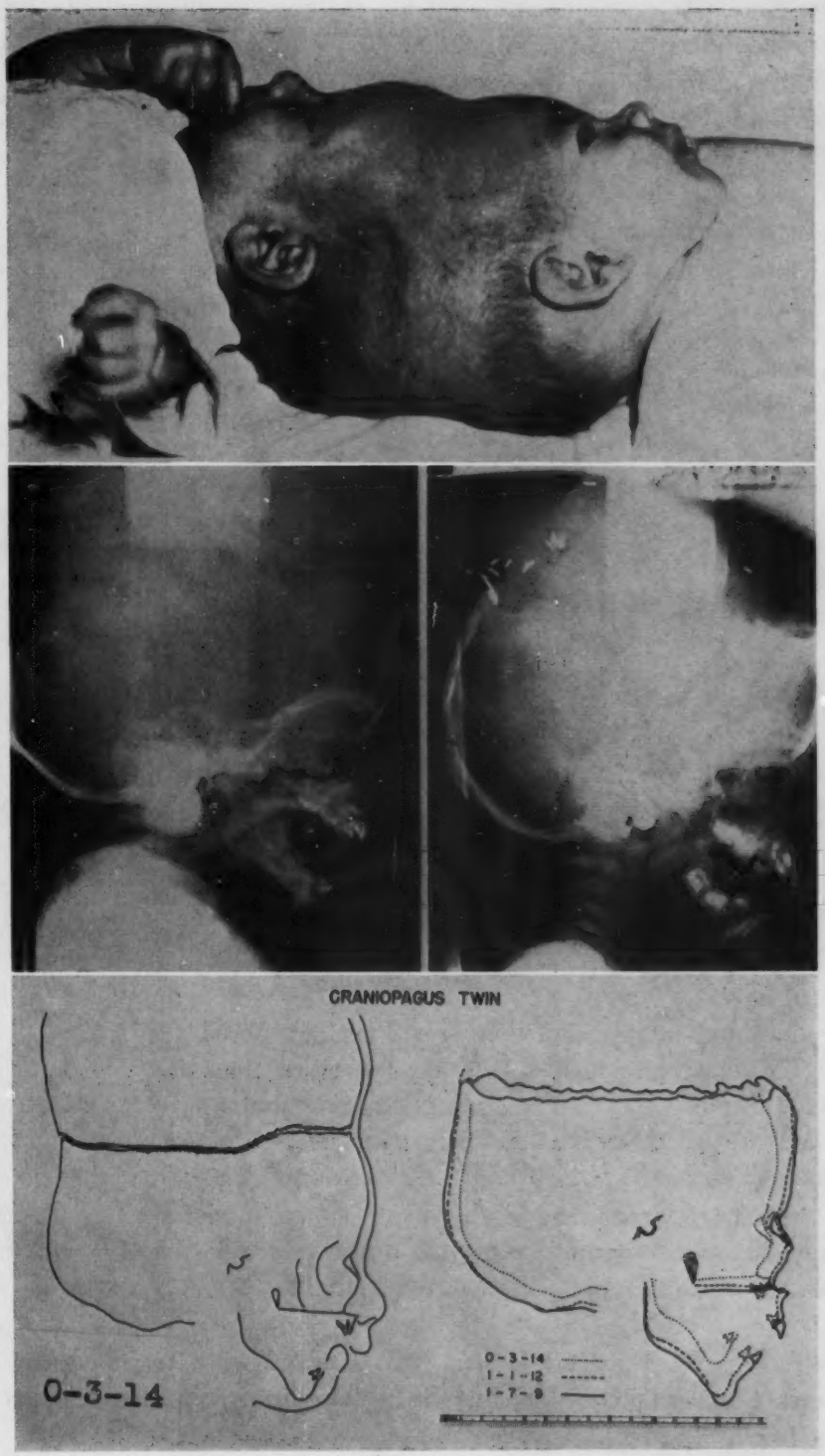

Fig. 13.—Craniopagus twins before and after surgical separation.

cleft of the nasal bones, the lip, the palate, and the anterior cranial fossa. The dependent mass of tissue extending from the base of the brain into the oral cavity probably contained neural tissue.

4. *Craniopagus twins:* Two sets of Siamese twins, joined at the top of the head, have been followed by cephalometric roentgenography. Serial films were obtained to plot the response to the surgical procedure and to document the growth behavior (Fig. 13).

Congenital Deformities of the Facial Skeleton.—

1. *Cleft lip and cleft palate:* Comparisons are being made between different kinds of clefts, the varying patterns of growth, the response to different surgical procedures, and the comparison between clefts and a series of normal infants.

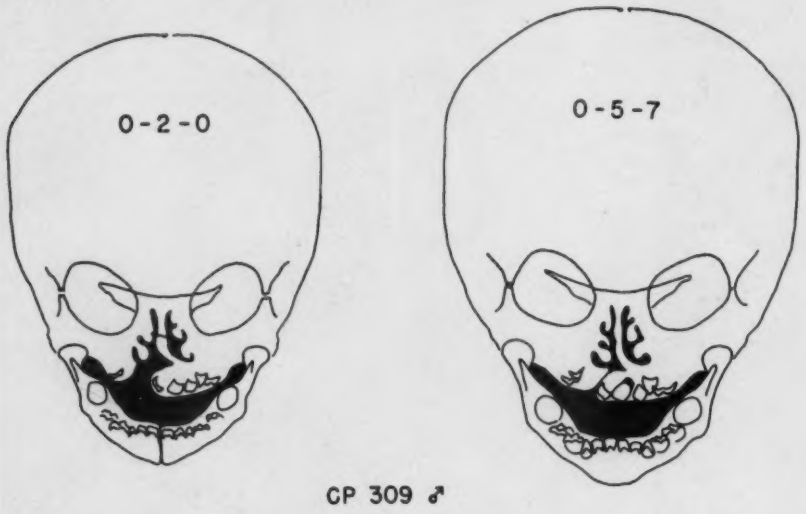

Fig. 14.—Early changes in the dimensions of the nasal chambers following lip repair in a complete unilateral cleft of the lip and palate.

Frontal and lateral cephalometric films have been utilized to study the changes in the architecture of the nasal cavities following repair of the lip (Fig. 14), alterations in the position of the premaxilla subsequent to two-stage cheiloplasty (Fig. 15), and the deleterious effects of the compression type of operation for repair of the lip and the alveolar process (Fig. 16).

Cephalometric documentation has increased our understanding of the structural and functional pathology of this anomaly complex and has provided a rationale for various aspects of therapy, including early orthodontic intervention.[12]

Clefts and their normal twins: Five sets of twins, in which one of the twins in each set has a cleft, are included in our present sample. A comparison between two brothers comprising one such set of twins is of interest. In this case, the child with the unilateral cleft of the lip and palate differs from his normal twin mainly in his somewhat flattened occiput, slightly smaller mandible,

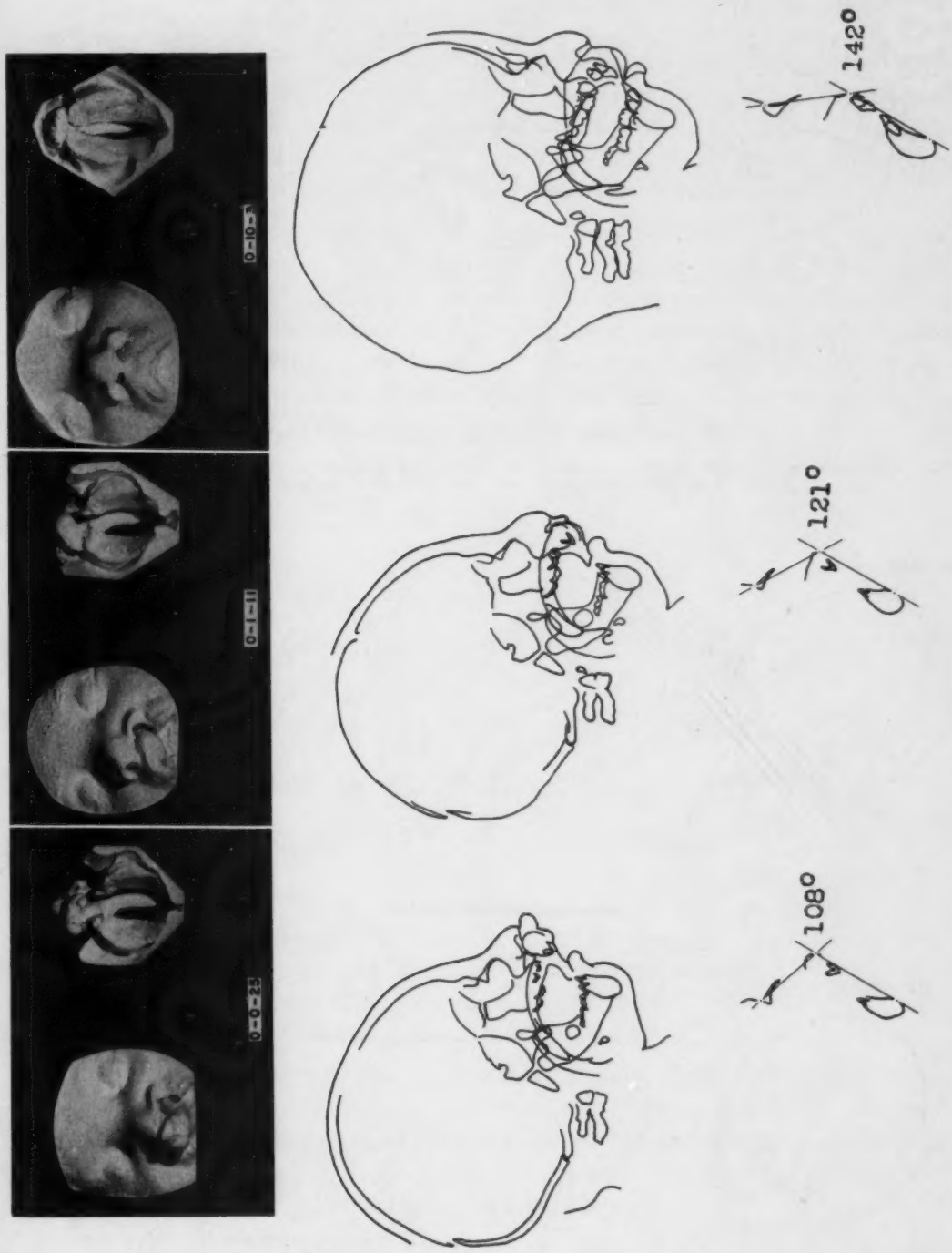

Fig. 15.—Early changes in the facial profile subsequent to two-stage lip repair for complete bilateral cleft lip and palate.

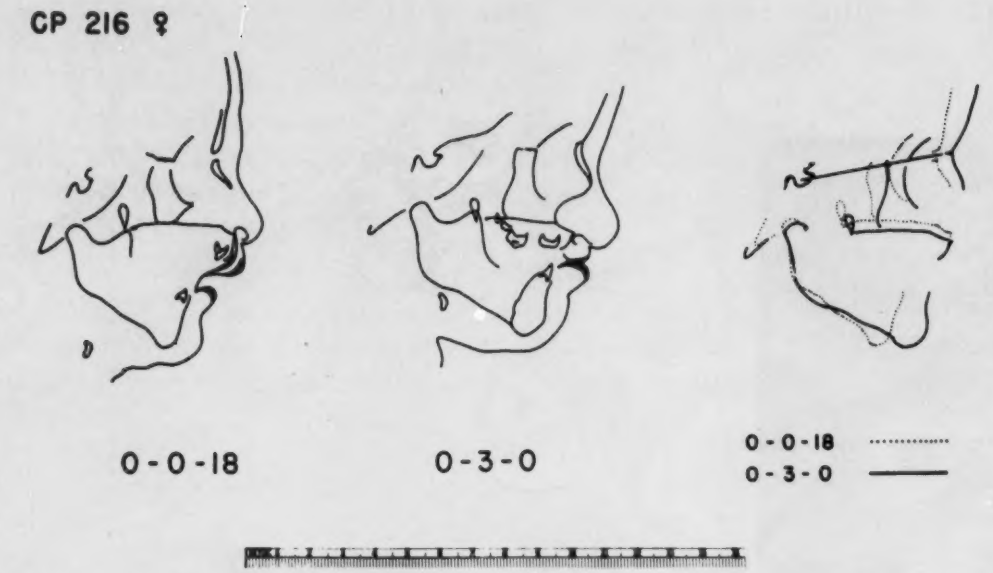

Fig. 16.—Arrested growth of the middle face evident at 3 months of age following surgical wiring and compression of the maxillae at 1 month of age.

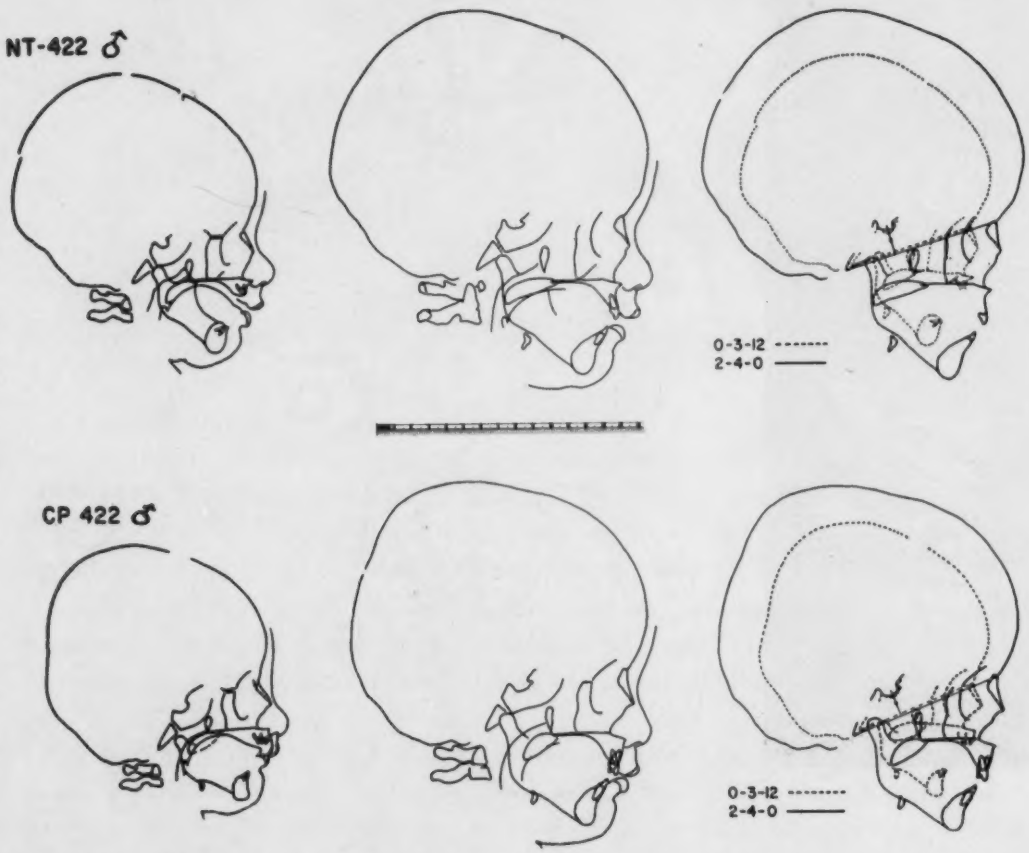

Fig. 17.—Growth behavior of male twins from 3 months 12 days to 2 years 4 months of age.

and shorter soft palate (Figs. 17 and 18). The differences in the position of the maxillary incisors reflect the localized deformity of the alveolar segment that is characteristic for such clefts.

2. *Mandibular micrognathia (Pierre Robin syndrome):* Data derived from these cephalometric investigations indicated that the micrognathic mandible of the infant possessed remarkable potentialities for growth.[7, 13] In most cases the increments in mandibular growth, as related to total facial growth, were eventually sufficient to produce a cosmetically satisfactory facial profile.

3. *Mandibulofacial dysostosis:* In England and in America this syndrome is named after Treacher Collins and on the European continent it is named after Franceschetti.[14] The latter described this syndrome as including, among other features: (1) hypoplasia of the facial bones, especially the malar bones; (2) malformation of the external ears; (3) macrostomia, high palate, and severe malocclusion; and (4) blind fistulas between the angles of the mouth and the ears.

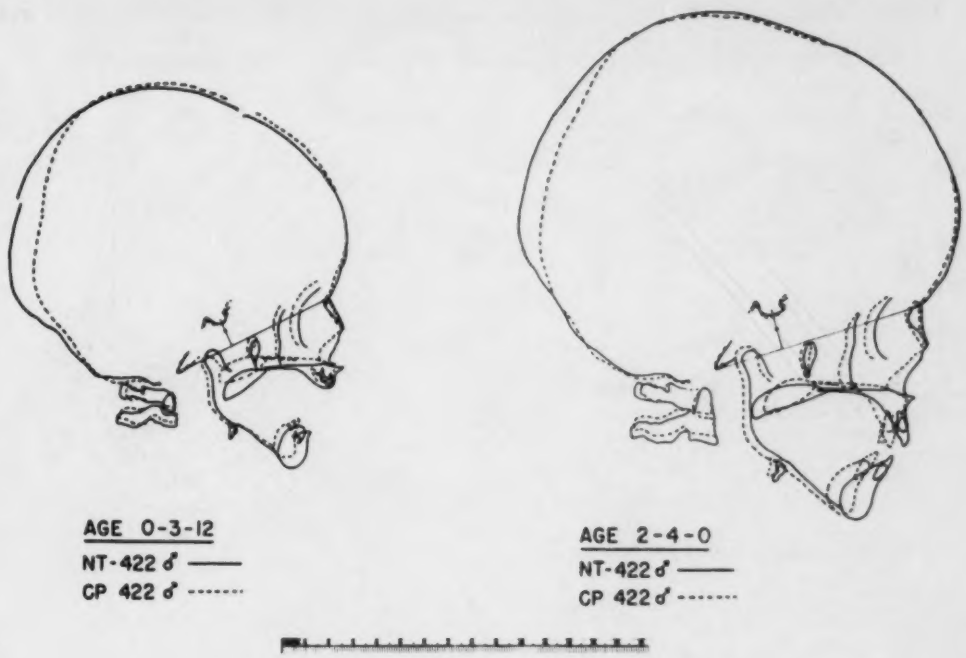

Fig. 18.—Comparison of twins shown in Fig. 17.

Although the basic pattern of the deformity is unchanged, a relative improvement in facial appearance has been noted clinically and documented cephalometrically (Fig. 19).

4. *Microtia:* Deformities of the external ear are of interest to the orthodontist, for they are part of an anomaly complex that may include any or all of the following associated anomalies on the same side of the ear defect: congenital deformity of the mandibular condyle, partial paralysis of the facial

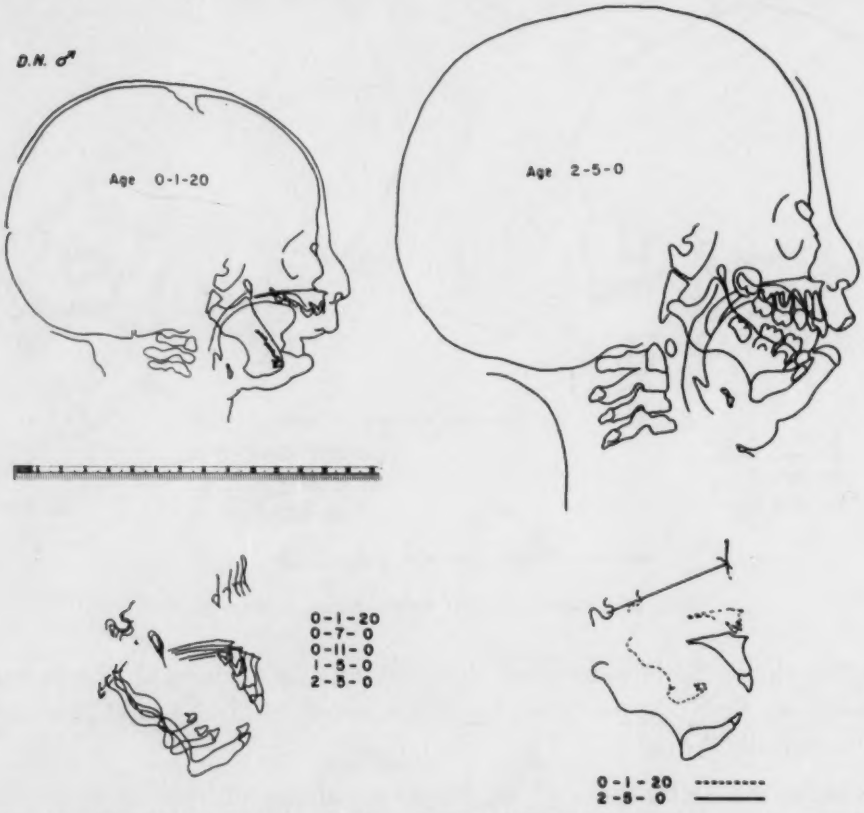

Fig. 19.—Mandibulofacial dysostosis. Lower left serial tracings were superimposed on the cranial base, as shown in Fig. 5. The lower right tracings were superimposed on nasion for analysis of changes in profile.

nerve, macrostomia, and blind fistulas between the angles of the mouth and the ears. As a result of the condylar deformity and the facial paralysis, severe facial asymmetry and malocclusion develop (Fig. 20).

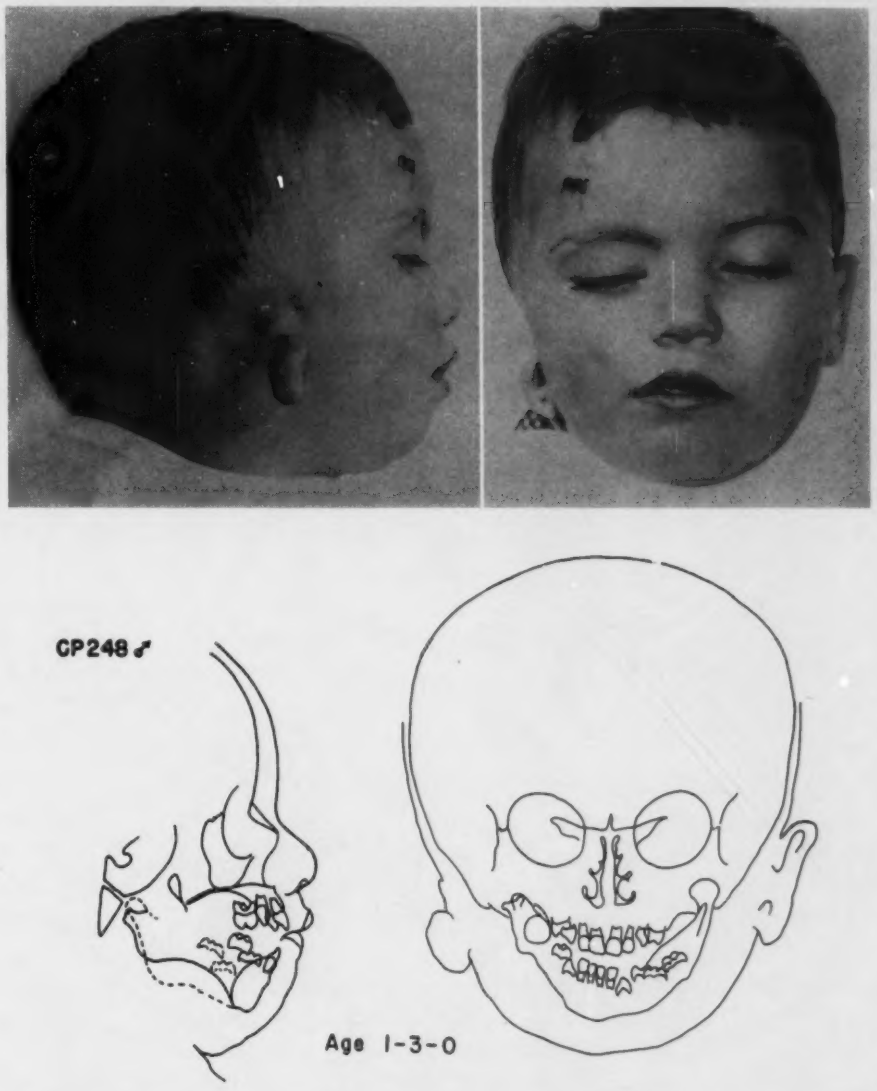

Fig. 20.—Microtia with congenital deformity of the mandible and macrostomia.

Longitudinal experience with such cases has indicated that, when there is early radiographic evidence of congenital condylar deformity with antegonial notching, the severity of the deformity will increase with age. Ultimately, there will develop a facial and dental asymmetry proportionate to the severity of the congenital insult.

The anomalies related to microtia are differentiated from the syndrome of mandibulofacial dysostosis by the absence of ophthalmologic pathology and by the presence of the malar bones.

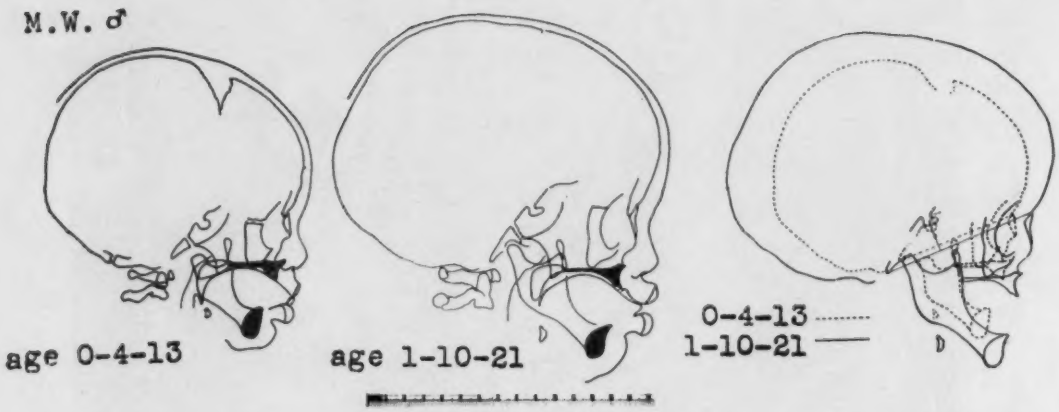

Fig. 21.—Serial tracings of infant with ectodermal dysplasia and complete anodontia.

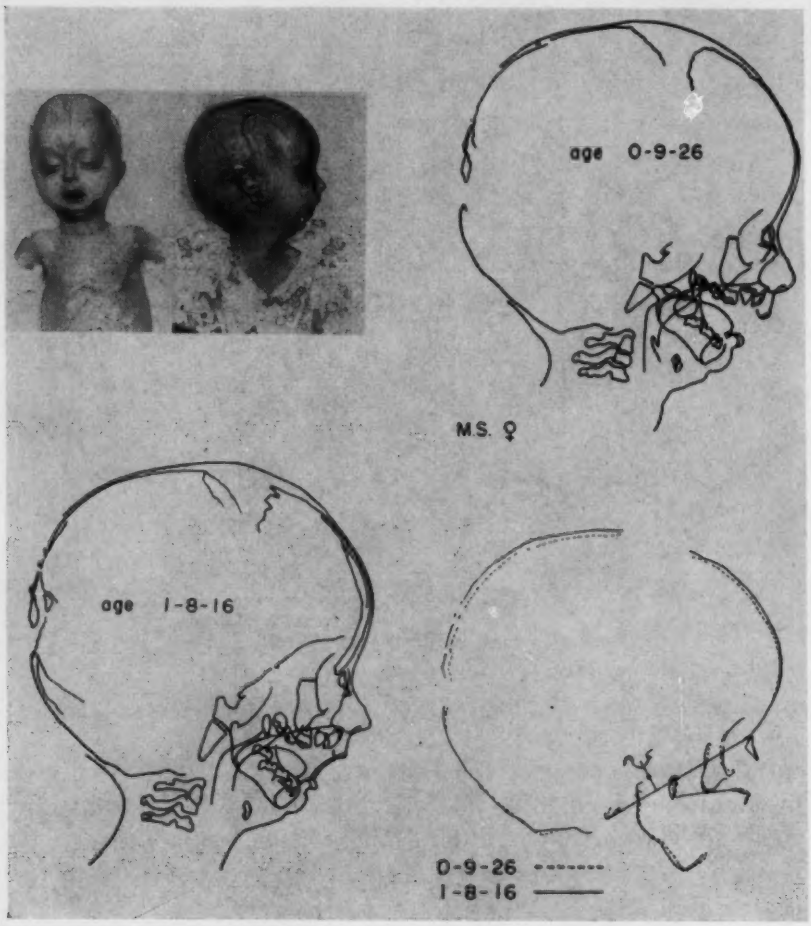

Fig. 22.—Progeria. (See text for discussion.)

Generalized Disturbances of Somatic Growth.—

1. *Ectodermal dysplasia with complete anodontia:* Brodie and Sarnat[15] published a serial cephalometric appraisal of a case of ectodermal dysplasia of the anhidrotic type with complete anodontia. The earliest record in their case was obtained when the patient was 2 years 10 months of age. They reported that complete absence of teeth does not significantly impair development of the face and the jaws.

In a similar case, a child has been under cephalometric study in this laboratory since the age of 4½ months (Fig. 21). Our observations on this case confirmed the conclusions of the previous investigators.

2. *Progeria:* This is a rare disease in which the child resembles a very aged person (Fig. 22). It is a curious fact that unrelated patients, male and female, of different racial strains, from various parts of the world, develop such strikingly similar facial characteristics, namely, a small face, a beaklike nose, underdeveloped jaws, absence of ear lobes, and alopecia.

Certain specific abnormalities in growth and development are regularly found. Analysis of cases of progeria has led to the belief that many of the abnormalities found are primarily the result of a premature aging process.

Cephalometric studies of three such patients have demonstrated that the odd facial appearance in progeria is the result of a disturbance in the rate of growth, with the major arrest in the facial skeleton.[16] The similar facial appearance of the edentulous octogenarian results from the loss of teeth, atrophy of the alveolar processes, and subsequent lack of support for the cheeks and lips, an entirely different process.

3. *Progeroid syndrome:* Characteristics suggestive of senility have been reported in children in association with dwarfism, microcephaly, and mental retardation. The case of such a patient has been followed in this laboratory from 2 months to 5 years of age. The cephalometric findings helped differentiate this case from progeria. In progeria, the size of the cranial vault approaches normal limits and the primary arrest is in the facial skeleton. In our case of progeroid syndrome, or pseudosenilism, the child was a severely dwarfed microcephalic whose growth disturbance probably began in utero and affected the neurocranium as well as the splanchnocranium.[17]

DISCUSSION

The techniques for sedation and the improvements in apparatus for cephalometric roentgenography of infants and small children have served to extend the research on growth and development of the human head. The wide range of research problems touched upon in this article reflect the usefulness of these tools to disciplines other than orthodontics. Indeed, much of this research would not have been possible without the collaboration of specialists in the fields of pediatrics, plastic surgery, and neurosurgery.

As with all specialties, orthodontic knowledge can be extended through multiprofessional collaboration on problems of mutual interest. More and

more, we find that these mutual interests prosper in accordance with the extent to which the professions help each other. Cephalometric roentgenography has provided a medium for the exchange of knowledge basic to many disciplines.

Although our concern has been primarily with pathologic processes somewhat remote from everyday clinical orthodontic experience, the information gained is nevertheless exciting in terms of its contribution to the biology of craniofacial growth. The intimate relation of structure and function is not always apparent until something goes drastically wrong. The experiments which Nature makes upon our fellow creatures are often unique in that they cannot be duplicated in the laboratory or reproduced at will in the clinic. These experiments of Nature on the growth of the head, if properly considered, will permit acquisition of new and useful information applicable far beyond the patients and the anomalies studied.

Certain findings reviewed in this report merit discussion in so far as they relate to existing concepts concerning the posture of the mandible and patterns of abnormal facial growth. The roentgenographic films of infants which Brodie[18] utilized in this study on the growth of the head in the normal human being were obtained from the Bolton Foundation. In that series the infants were not sedated and, after approximately 1 year of age, the headplates had been taken with the patients sitting upright. Also, the teeth were forced into occlusion in most of the films taken after the patients reached 1½ or 2 years of age. These factors influenced the position assumed by the mandible, and hence its relation to other parts of the head.

Ortiz and Brodie,[5] in their cephalometric investigations of the growth of the human head in the first three months of life, were unable to report in any detail on mandibular growth. With respect to mandibular posture they wrote: "... It was impossible to state with finality anything about the maintenance of mandibular position for the reason that the infant was frequently kept quiet by placing a nursing bottle in the mouth."

The technique of sedation for cephalometric roentgenography of infants is especially valuable in view of the evidence that it does not alter postural relations of the mandible. Postural control over the mandible and the tongue are as essential in the sleeping state as when the infant is wide awake.

The similarity between mandibular posture of the infant in the supine position and sitting upright at a later age should not be too surprising. In the infant basic postural adjustments are related to the supine position, and the requirements for postural control of the mandible and its contiguous structures are the same as in the upright position. The chief requirement for such regularity is that similar head to neck to body relations be maintained, whether the child is supine or upright.

With respect to the anomalies studied, it is quite evident that not all congenital aberrations are alike in terms of the severity of the original deficiency or distortion. Nor are all anomalies alike in the capacity of the defective organ to recover and to grow at a normal rate. These differences in behavior are reflected in the various patterns of mandibular growth reported herein.

In the Pierre Robin syndrome, the micrognathic mandible of the infant is capable of remarkable recovery in terms of growth. Several children in this series have gone on to develop Class I occlusal relations. Evidently, the micrognathia in these cases is due to a disturbance in rate of development and involves no permanent injury to growth sites.

On the other hand, the condylar deformity noted in some cases of microtia represents a dysplasia or irreversible damage to an important growth site. As might be expected in such cases, the severity of the deformity will increase with age.

A third pattern of behavior is evident in the syndrome of mandibulofacial dysostosis. The characteristic distortion remains and becomes neither better nor worse with age.

Recognizing that certain congenital deformities will show spontaneous improvement in time, while others will remain the same and some will grow worse, is of practical value in counseling parents and in treatment planning. When the pattern of mandibular growth is such that spontaneous improvement is to be expected, as in the Pierre Robin syndrome, no intervention is indicated other than the lifesaving procedures sometimes necessary in the perinatal period.[6, 14] In mandibulofacial dysostosis where the mandibular deformity remains essentially the same, plastic reconstruction may be geared to optimal conditions for surgery, such as the achievement of maximum growth. On the other hand, where there is cephalometric evidence that the mandibular deformity is progressively getting worse, as in severe microtia or in acquired condylar arrests from trauma or infection, early intervention by surgical means is worthy of consideration.

SUMMARY

Cephalometric roentgenography of infants and small children has been made possible through the use of sedation and the design of cephalometric apparatus specifically suited to the handling of infants.

A detailed statement of the theory and practice of secobarbital sedation was deemed essential, so that the hazards as well as the possibilities might be fully understood by those who would undertake similar research.

The cephalometric equipment was designed to conform with the Broadbent-Bolton standards. The principal deviation was that a 3 foot distance from the frontal tube to the transporionic axis was employed instead of the standardized 5 foot distance. The lateral tube was mounted at the conventional 5 foot distance from the midsagittal plane of the head holder.

It was found that rest position of the mandible, as recorded in the sedated infant, was remarkably constant for that infant. The same mandibular posture was obtained at a later age in the same child when similar examinations were performed without sedation and with the child in the supine position on the cephalometer for infants. Similar rest positions for the mandible in the same child were registered when lateral headplates were finally obtained with the

child sitting upright in the Broadbent-Bolton cephalometer. The primary requirement for such regularity of mandibular posture was the maintenance of similar head to neck to body relationships.

Serial investigations of a variety of congenital deformities of the brain case and facial skeleton were presented to demonstrate the value of these techniques in the study of abnormal patterns of growth of the head in infants and small children.

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A CEPHALOMETRIC AND HISTOLOGIC STUDY OF THE EFFECT OF ORTHODONTIC EXPANSION OF THE MIDPALATAL SUTURE OF THE CAT*

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INTRODUCTION

IN PRESENT orthodontic thinking concerning the effect of orthodontic expansion in the maxillary facial region, two schools of thought seem to prevail. Each, in its own way, has had a modifying influence on the plan of orthodontic treatment as well as on the age at which treatment should be initiated in individual cases.

One school of thought contends that in the usual type of orthodontic treatment any expansion of the maxillary dental arch is confined to the teeth and the alveolar bone immediately surrounding them. This opinion has been expressed by Brodie, Downs, Goldstein, and Meyer[1] as follows: "Our treatment seems to have little or no effect on any structure other than the alveolar process." Björk[2] has written more recently in support of this concept: "The effect of orthodontic treatment based on the use of fixed appliances and activators is essentially restricted to changes in the shape of the alveolar or dental arches."

The other school of thought, primarily propounded by prominent European orthodontists, expresses the concept that expansion forces can open and widen the midpalatal suture of the maxillary facial complex. The opening of the maxillary palatal suture is thought to encourage the apposition of new bone in the suture area. As a result of this, the maxillary palate itself is said to widen and the width of the nasal cavity is said to increase. Schwarz[3] has expressed this concept as follows: "The bursting of the palatine suture widens the upper jaw by separating the jaw in the region of the median suture and encouraging bony apposition at the submucous bony cleft which is kept open." Korkhaus[4] supports this opinion and has stated that a permanent expansion of 10 mm. and more can be obtained in some cases, increasing the width of the palate and the intranasal space the same dimension.

These opinions formulated by leading exponents of each concept have been included to emphasize the fact that a marked difference in opinion exists. Because they are fundamental in character, these differences, have an effect upon orthodontic treatment.

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The purpose of this investigation was to contribute to the present body of information relating to the effect of orthodontic expansion in the maxillary area. The cat was used as the experimental animal. Specifically, the following questions were posed for research study:

1. Does orthodontic expansion in the maxillary region of the cat open the midpalatal suture?
2. Does histologic study indicate deposition of new bone in the midpalatal suture of the cat subsequent to orthodontic expansion?
3. If orthodontic forces are capable of opening the midpalatal suture of the cat, are they concomitant effects upon the surrounding maxillary sutures?
4. If orthodontic forces are capable of opening the midpalatal suture, is there evidence relative to the extent to which the midpalatal suture can be opened?
5. What are the pertinent differentiating factors which must be recognized before the results of this study may be stated with reference to present thinking regarding the effects of orthodontic expansion in human beings?

REVIEW OF LITERATURE

The divergent opinions related to the opening of the maxillary midpalatal suture following the application of orthodontic expansion forces form the basis of this review. It is not within the scope of this thesis to review literature concerned with tooth movement, which has been extensively presented in recent publications by Reitan[5] and Hemley.[6]

In an article published in 1860, Angell[7] described an expansion appliance which was activated by a central screw. The patient was instructed to turn the screw periodically, and this created laterally directed forces. In his report, Angell stated that at the end of two weeks the maxillae were separated as evidenced by the development of a space between the two maxillary central incisors.

In support of this concept, Goddard,[8] in 1894, expressed the belief that a deposit of osseous material within the open suture would help retain added arch width. In Goddard's opinion, the deposition of new bone was thought to occur with the same rapidity as the healing of a bony fracture. Although Matteson[9] agreed with Angell and Goddard with regard to suture opening, he disagreed with Goddard in one respect. It was Matteson's contention that, although the two maxillary bones are separated following the application of mechanical forces, a concomitant stretching of the soft tissues of the palate takes place. In his opinion, the tension of the soft tissue would cause "a relapse" of the maxillary bones to the original position when mechanical forces were removed.

As evidence that maxillary midpalatal suture opening occurred, Ottolengui[10] stated in 1905: "... that the midpalatal suture is opened I am sure ..., for I have felt the edges of both bones with my fingers, and that is convincing. I have

also probed with needles.'' Ottolengui enlarged upon his thinking by stating that when the maxillary midpalatal suture is opened the two maxillary bones are drawn away from each other while the position of the vomer, which is inserted at the nasal crest formed by the union of these two bones, remains unchanged. Willis[11] and Wright[12] suggested that the opening of the maxillary midpalatal suture would result in the straightening of a deviated nasal septum originally present in a constricted upper arch. Furthermore, they concluded that the expansion of the maxillary arch would result in a concomitant widening of the nasal floor. In their opinions, maxillary expansion was the only means of improving nasal deficiency. Thus, along with improvement of masticatory function and esthetic alignment of dental arches, expansion treatment was advanced as an important measure in the establishment of adequate nasal respiration.

In considering the influence of opening the maxillary midpalatal suture upon the nasal cavity, Brown[13] stated in 1909 that there was a separation of the nasal processes and the nasal bone following orthodontic expansion of the maxillary arch, which resulted in an immediate increase in space within the nares. This statement was based upon Brown's expansion of the maxillary arch of a fresh cadaver and his reported success in opening the suture. Measurements taken between two arbitrary points chosen at the base and upper third of the nose showed that following the mechanical opening of the suture there were respective increases of $\frac{1}{8}$ and $\frac{1}{16}$ inch in the width of the nose. Following the procedures outlined by Brown, Dean[14] expanded the upper arch of a fresh skull and made instrument measurements within the nasal cavity. He found that the distance across the posterior nares just posterior to the inferior turbinates increased 2 mm. after expansion and that the distance across the posterior nares just superior to the posterior termination of the middle turbinates increased 1.5 mm. At the same time, the distance from the vomer to the outer wall of the nose on the left side increased by 1.5 mm., whereas the right side showed no increase. He pointed out that, although the suture was opened with an even force, the displacement of the two maxillary bones was not always symmetrical. Three years later, Dean[15] reported his measurements on living human beings and confirmed the results he had obtained on fresh skulls.

In contradiction to Dean's results, Ketcham[16] reported that he failed to open the maxillary midpalatal suture on a fresh cadaver of a 5-year-old child. As a result of expansion force the arch width was increased 5 mm., at which point the right buccal alveolar plate fractured under the influence of the pressure. Measurement of the distance across the nasal cavity following the application of pressure showed no increase in the width of the nasal cavity associated with the increase in arch width.

In 1909, Landsberger[17] introduced the application of a radiographic technique to evaluate the effect of orthodontic expansion in human beings. By means of roentgenograms taken before and after orthodontic treatment, he found that lateral pressures applied to the buccal teeth resulted in an opening of the midpalatine suture. Similar reports were also presented by Pullen,[18] Dewey,[19] and Chateau.[20]

These reports were not completely accepted by Ketcham,[16] who warned against accepting evidence furnished by radiographs which he felt could be misleading. He suggested that a thick nasal spine or vomer might give the impression that the suture had been opened. This diversity of opinion regarding the validity of radiographic evidence appears to have been a factor in stimulating increased interest and study related to the anatomic and histologic structure of the maxillary midpalatal suture. In 1912, Pullen[18] described the fibromembranous connective tissue of the suture as allowing for extreme mobility of the facial bones united by the suture, so that force exerted by expansion of the dental arch easily influences the growth of the maxillary bones. Pullen elaborated on this concept and functionally differentiated areas of the suture, contending that the anterior third of the maxillary region responds more readily to readjustments following the opening of the maxillary suture.

Wright[12] agreed with Pullen's thinking that the suture is a growth center united by connective tissue fiber which prevents it from closing. After examining a collection of dried skulls, he also defined the different variations existing within the sutural complex. Wright drew attention to possible differences in age gradients by reporting that the intermaxillary and palatine sutures do not ossify until the age of 50 years.

A much earlier age was reported by Izard,[21] who also studied the configuration of the suture on a collection of dried skulls. From his investigation, he reported that the midpalatal suture starts to close around 16 years of age and that by 25 years of age the suture is ossified. For this reason, he stated that expansion treatment should be started between the ages of 7 and 12 years.

In summary, it can be stated that investigators were aware of the extremely delicate anatomic relation existing between the maxillary and facial bones. However, their opinions differed markedly as to whether or not the sutures in the maxillofacial region could be appreciably influenced by orthodontic forces. There was also a marked difference in theoretical interpretations of clinical observations.

The first experimental approach in relation to the separation of the maxillary bones was presented by Dewey.[22] He applied intercuspid expansion on 2-year-old dogs for eighty-five days. As a result of his experimental procedures, he found that the sutures of the intermaxillary area were more closed than in the control animals "because of an extreme activity of the connective tissue binding." He also observed that the cuspid teeth had been moved outward but that they were still surrounded by alveolar bone. His conclusions, based on unpublished histologic data, stressed that forces placed upon teeth in an effort to open the suture resulted in "a development of bone through the entire maxilla and nasal space" which accounts for the improvement in the individual.

As a result of clinical observations, Federspeil[23] agreed with Dewey in that he firmly denied that the opening of the suture was possible. Federspeil presented observations on six patients undergoing expansion treatment. During the course of treatment he anesthetized the hard palate, surgically reflected the overlying soft tissue, and found no opening of the suture.

The introduction of the cephalometer by Broadbent[24] established a reliable method for investigation which has overcome many of the earlier criticisms of radiographic evidence. Utilizing this technique, Brodie and associates[1] reported a preliminary cephalometric investigation of Class I, Class II, and Class III cases. Although no specific statements regarding changes in the midpalatal area were made from this broad study of various types of malocclusions, the authors stated that growth accounts for a considerable part of the changes which take place during orthodontic treatment. They denied any growth stimulation as a result of orthodontic procedures and stated: "Our treatment has seemed to have little or no effect on any structure other than the alveolar process."

The conclusion that orthodontic forces per se do not stimulate growth may be contested, in part, by the results of Harvold's[25] experiment. Harvold, in 1949, surgically created a cleft of the palate in a monkey and subjected it to expansion therapy in the maxillary area. In order to study the reaction of the bones surrounding the maxilla, and in particular the surrounding sutural area, he alizarinated the monkey prior to the insertion of the orthodontic appliance. After histologic study, Harvold concluded that expansion therapy affects all the maxillary sutures by stimulating the growth of bone in accordance with the application of force. These experimental findings may not contribute appreciably to the much debated question regarding the midpalatine suture, since a surgical cleft had been created in this area. It may not be possible to extend this information to normal cases.

In support of the results of Harvold's experimental work on sutural changes produced by orthodontic expansion, the work of Bober[26] should be included. Using experimental animals, Bober concluded that expansion of the maxillary dental arch resulted in an opening of the midpalatal suture which is followed by a straightening of the nasal septum. He observed invigorating effects on the pituitary gland.

Among the studies specifically devoted to the effects of orthodontic expansion on the maxillary midpalatine suture, those of Derichsweiler[27] must be mentioned. After studying frontal roentgenograms taken of patients before and after orthodontic expansion, Derichsweiler concluded that expansion treatment results in the separation of the two maxillary bones. He theorized from his radiographic investigation that the opening of the midpalatine suture is comparable to a "greenstick" fracture which later fills with new bone, in this case resulting in an enlargement of the nasal cavity and a widening of the external nares.

In contradiction to Derichsweiler's findings of midpalatal suture opening in persons who do not have cleft palate are the findings of Subtelny and Brodie.[28] Using cephalometric laminagraphy, a body-sectioning radiographic technique, they investigated the changes that occurred at different depths within the maxillary area of patients with and without cleft palate subsequent to orthodontic expansion. Although the expansion procedures in the cleft lip and cleft palate patients did result in a repositioning of the two maxillary segments, no evidence

of repositioning of the maxillary segments was reported in the group of noncleft palate subjects. In the latter group, changes in the maxilla resulting from expansion forces were confined to the teeth and the alveolar bone surrounding them. As a result of specific measurements, Subtelny and Brodie stated that in the noncleft palate sample: "The distances between unerupted teeth, the lateral walls of the nasal cavity and the lateral margins of the maxillary sinuses remained constant."

Cauhépé[29] also denied that expansion treatment would result in an opening of the midpalatine suture and claimed that the results obtained by this treatment are restricted to the alveolar bone. Yet he admitted that it is possible to produce a sutural fracture of the two maxillary bones by lateral application of strong forces. This treatment, he said, is surgical in nature and not orthodontic. With the work of Cauhépé, then, a difference in midpalatal suture reaction to expansion force is introduced, considering the degree or gradients of force applied.

Extremes in gradients of force were investigated by Chateau and Chateau.[30] Although in their series of clinical reports the investigators did not elaborate on their methodology, they distinguished between traumatic opening of the midpalatal suture or "osteotomy" performed within a few days and expansion of the upper arch performed over a period of months. The two methods of treatment were evaluated radiographically, but no difference in the final results was reported. It was concluded that both osteotomy and light expansion of the maxillary arch resulted in the formation of a median callous at the midpalatal suture following retention. The opening of the midpalatine suture was found to restore normal breathing and improve the general health of the patient.

To date the question of the influence of expansion upon the maxillary midpalatal suture seems unresolved. Many orthodontists feel that the opening of the suture can occur only under the influence of excessive forces. Others claim that it can occur under the influence of any orthodontic force and maintain that it should be encouraged because of the numerous beneficial effects to be derived thereby. Still others reject the premise that midpalatal changes occur as a result of expansion regardless of the degree of force applied. Certainly the whole subject seems to be somewhat confused by the fact that various channels of evidence have not been combined. It was felt that a study combining cephalometric and histologic data as well as clinical observations would permit evidence to be accumulated and presented in an organized fashion.

METHODS AND MATERIALS

For the purposes of this study, nine cats (six male and three female) were obtained from the same stock colony. They were carefully selected with regard to physical health and ranged in age from 18 to 24 months. This age range can be roughly estimated to approximate 14 to 16 years of age in the human being.[31] The choice of this age range was based on the premise that at this time natural growth, if any, is considerably diminished in the cat and will not interfere with the experimental procedures and interpretation.

It was felt that the use of a younger age sample in an initial study could complicate the interpretation of experimental findings. For example, it might not be possible to distinguish between natural growth and growth resulting from mechanical stimulation. On the other hand, if orthodontic expansion does result in an opening of the intermaxillary suture in an almost fully grown cat, the results may be more readily applied to a growing young animal. The reverse may not be possible.

The dentition of the cat has been extensively described elsewhere[32, 33] and need not be repeated here. However, it is important to note that in the cat there are two distinct sets of teeth, a decidious and a permanent dentition, "both of which develop and erupt in the same relative order as those of the human dentition."[34] Distinct anatomic differences, in comparison to human teeth, are noted in the size and shape of the cat's teeth as well as in the fact that the entire maxillary dentition overlaps the mandibular dentition. A lack of interdigitation of teeth proved to be an advantage, since any interdigitation might serve to impede orthodontic expansion in the maxillary arch.

The calcification of the maxillary cuspids, which are the last teeth to erupt into the arch, is completed at 9 months of age.[35] Theoretically, at this time the development of the maxillary arch is close to completion.[32] Thus, forces were not applied on rapidly developing teeth. With the knowledge that the calcification of the maxillary cuspid is completed by 9 months of age, it was assumed that its complete eruption is attained by 18 months of age, which was the minimal age of the experimental animals. In the cat, the maxillary cuspids are firmly implanted in their sockets. They are easily accessible and nicely shaped for the adaptation and cementation of an orthodontic band, which is an important step in the technical procedure of appliance construction.

The cats were fed fresh meat and milk once a day. They were weighed periodically (at the beginning, at the middle, and at the end of the experiments), and the results were tabulated. As far as possible, the experimental animals were maintained under similar environmental conditions.

Records Attained Prior to the Application of Orthodontic Forces.—Each cat was sedated prior to the attainment of any records or the construction and insertion of orthodontic appliances. This procedure was necessary to insure complete immobility of the animal while critical experimental records were being obtained. Nembutal sodium, injected intraperitoneally, was the sedative of choice. A dosage of 1 c.c. of Nembutal sodium per kilogram of body weight was found to keep the animal under deep sedation for a minimum period of one hour.

Subsequent to adequate sedation, impressions were taken of the maxillary dental arch and palate. An alginate impression material was used in this study. Special acrylic trays were constructed to fit the mouth and hold the impression material. Frequently the cat appeared to be extremely sensitive at the insertion of the tray and impression material. To maintain the tray within the mouth for as short a time as possible, warm water was used with impression powder.

This seemed to accelerate the setting time. After an acceptable impression was secured, the two cuspid cavities were pinned with a small piece of 0.016 inch round steel wire. This served to prevent an easy breakage of the long and isolated cuspids upon removal of the stone casts.

Following this procedure, lateral and frontal cephalometric headplates were obtained with the cat still deeply sedated (Fig. 1). These records were necessary to determine whether or not any appreciable increase in head dimensions occurred in any area other than the maxillary area itself during the experimental procedures. In this way, it could be ascertained that the analysis was not based on a naturally growing animal.

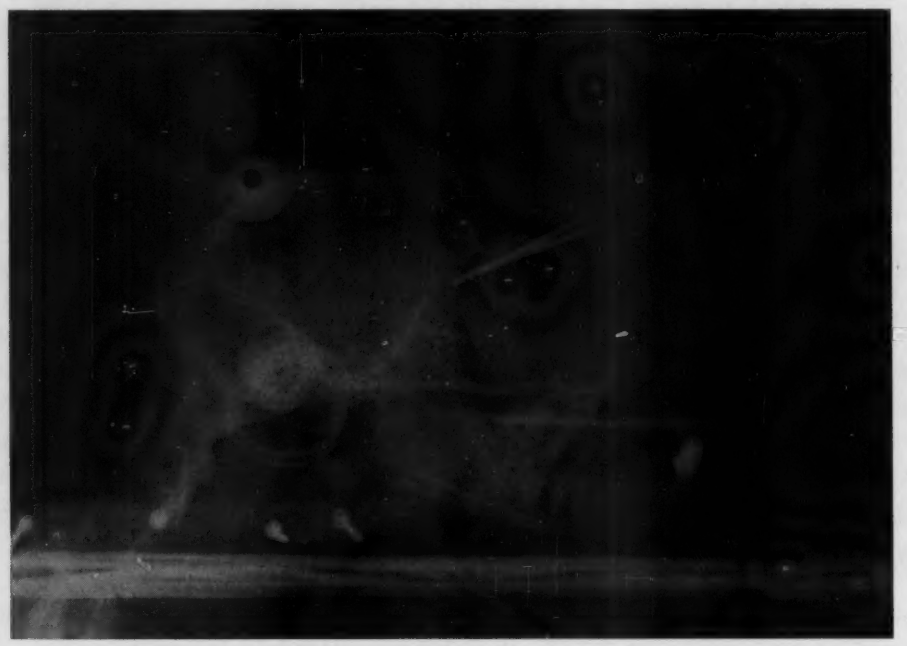

Fig. 1.—Lateral cephalogram of a cat positioned in the head holder. The long steel rods point to orbitale and the short steel rod points to nasion.

The cat's body and head were supported within a wooden box with two removable steps. One of the steps supported the anterior legs of the cat and the other supported the head. A special head holder was designed to fulfill all the principles of serial cephalometric roentgenography. For proper positioning of the cat's head, the external auditory canals alone could not be used. In the cat the external auditory canals are formed of cartilage and connective tissue. They are relatively long and flexible as they pass downward and medially to continue with the bony ear canal. The flexibility of the cartilaginous tube precluded an exact repositioning of the cat's head at a future date. This problem was overcome by the construction of a special head holder which was fixed to the step supporting the cat's head (Fig. 2). It was used in conjunction with a Margolis cephalostat.[36]

The devised head holder consisted of three sliding steel rods, calibrated in 1 mm. intervals. After the cat was positioned within the Margolis cephalostat,

with the carposts in place, the two laterally located steel rods were adjusted to press into a notch located at the posterior lateral aspect of the left and right bony orbits. Resulting from a lack of continuity between the zygomatic bone and the frontal bone, these two notches are easily located by palpation. For the sake of convenience, these reference points were termed "orbitale." The third rod, centrally located, was adjusted to contact the soft tissue overlying the junction between the nasal bones and the frontal bone. This landmark was termed "nasion."

After the head was properly positioned lateral and frontal cephalograms were taken. To insure similar repositioning at a future date, the readings on the three calibrated rods were recorded.

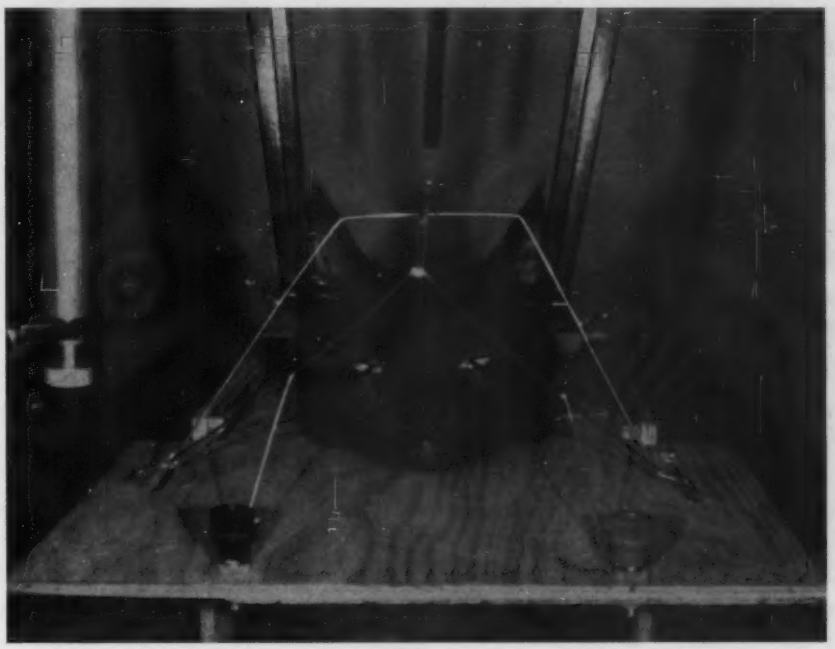

Fig. 2.—A frontal view of a sedated cat positioned within the specially constructed head holder.

Appliances Used.—In order that the action of different orthodontic forces might be analyzed, the nine cats were divided into four groups. The "control" group, consisting of three cats, was not subjected to any orthodontic forces. The other three groups, each composed of two cats, were respectively subjected to intermittent orthodontic expansion forces, to continuous orthodontic expansion forces, and to intermittent contractive orthodontic forces. It was felt that, if orthodontic expansion opens the maxillary palatal suture, it would be interesting to note the effect of forces directed in the opposite direction. In essence, this would serve as an added control as well as extend further useful information.

After the necessary records were obtained the sedated cat was tied to a board and its mouth was kept open by a wooden block inserted between the

two jaws. Bands 0.003 inch thick and 0.125 inch wide were adapted directly to the cuspids as close to the gingiva as possible. The various appliances were then constructed and cemented into place.

Intermittent expansion was obtained by a U-shaped round gold wire, 0.025 inch in diameter, which was opened to provide expansion and then cemented in the mouth after slight digital compression to permit its insertion (Fig. 3, *A*). The purpose of this expanded wire was to increase the intercuspid width. After completing its action, this type of appliance allows for a period of rest until the appliance is reactivated. Continuous expansion was attained by a modification of the Arnold expansion appliance[37] (Fig. 3, *B*). A tube, 0.030 inch in external diameter and 0.025 inch in internal diameter, was soldered to the left band. It extended medially toward the right cuspid tooth. A 0.024 inch round wire soldered to the right band extended medially toward the left cuspid tooth and passed into the afore-mentioned tube. Force was attained by the compression of a coil spring, 0.009 inch by 0.056 inch, which was placed on the post between the tube and the band. This appliance increased the intercuspid width in a continuous and uninterrupted manner.

Contraction was obtained by a U-shaped gold wire appliance, 0.025 inch in diameter, similar to the one used for intermittent expansion (Fig. 3, *A*). The loops were closed instead of opened prior to the insertion of the appliance. The purpose of this appliance was to decrease the intercuspid width or to constrict the dental arch in the region of the maxillary cuspids.

Records Attained Subsequent to the Application of Orthodontic Forces.— After an adequate increase in the intercanine width had been attained under the influence of orthodontic forces, all the afore-mentioned experimental records were repeated. New impressions, new stone casts, and new cephalograms were obtained and analyzed according to standard procedures. The new casts were compared with the ones taken prior to the application of orthodontic forces to indicate how much tooth movement was obtained. The cats subjected to expansion forces had registered increases of 4 to 7 mm. in the intercanine dimension prior to their sacrifice. An increase of 7 mm., which was attained in two of the cats, represented almost one-half the original distance between the two cuspids prior to the insertion of the appliance. Two cats, one each from the continuous and intermittent expansion groups, were sacrificed after 4 mm. of expansion had been attained. Differences in the amount of expansion were purposely desired. An attempt was made to determine whether tooth movement and the opening of the suture occurred synchronously or independent of each other and whether there was a correlation between the opening of the suture and the extent of expansion.

Lateral and frontal cephalometric headplates were again obtained with the cat's head positioned within the specially constructed head holder. Care was taken to duplicate exactly the original head position within the head holder. The cephalometric headplates taken before and after expansion were traced on acetate paper and then superimposed for purposes of comparison. The composite tracings were first superimposed on the external cranial outlines to determine whether any increase in head and facial dimensions had occurred during the

A.

B.

Fig. 3.—*A*, A cat subjected to intermittent contraction forces. Notice crowded condition in the lower anterior incisors; the cat is not able to close his mouth. The appliance was used to produce intermittent contractive and expansive forces.

B, A cat which was subjected to continuous expansion forces. Note position and relation of the upper cuspids to the lower cuspids.

experimental procedures as a result of growth. The tracings were then superimposed on the contour of the hard palate to evaluate changes in the maxillary facial area.

Sacrifice of Animals and Preparation for Histologic Examination.—The cats were sacrificed by an excessive inhalation of ether after sedation with Nembutal. The upper jaw of each cat was sectioned from the animal by the use of carborundum disks. This procedure was followed in an effort to avoid distortion of the parts of the upper face. In an added attempt to avoid distortion of parts, the soft tissue was not dissected from the skulls.

Immediately thereafter the maxillae were prepared for histologic examination. Several of the jaws were decalcified for histologic examination, while others were studied by the use of ground sections. The decalcified sections permitted a direct visualization of the organic connective tissue and cellular structures. Changes within the bony matrix were analyzed and then the bone changes were interpreted.

The five decalcified specimens were fixed in a 10 per cent solution of neutral formalin for forty-eight hours, washed in running water, and then decalcified in a 5 per cent solution of trichloroacetic acid within a freezing unit. This procedure was followed to secure a good preservation of the organic matrix during the process of decalcification. Complete decalcification was generally obtained at the end of three weeks.

Once decalcification was completed, the jaw was cut into five parts: (1) the premaxilla (PM), (2) the maxilla (M), (3) the palatine bone (P), (4 and 5) the left (L) and right (R) cuspids with their surrounding bony structures. The approximate location of these parts was determined by x-ray examination prior to decalcification. Each part was washed overnight in running water, then dehydrated, and subsequently cleared and embedded in paraffin.

Serial cross sections of the suture areas were then cut from specimens embedded in paraffn. In order that the alveolar and periodontal tissue reactions of the maxillary cuspids might be registered, the right tooth was cut into longitudinal sections while the left tooth was sectioned perpendicularly to the long axis of the tooth. Sections 6, 10, and 20 microns thick were obtained. They were stained with hematoxylin and eosin and with Heidenhain's azan stain.[38] In specific instances, when it seemed possible to gain added information, sections were stained with a modified solution of Cretin,[39] and Grandis and Mainini[40] for histochemical examination.

The maxillae to be used for examination by ground sections were fixed in 90 per cent alcohol for forty-eight hours. Each jaw was then divided into two parts: (1) a large part consisting of the premaxilla, the maxilla, the palatine bone, and the right cuspid and (2) a smaller part consisting of the left cuspid, its surrounding bony tissue, and the left third incisor. This small incisor is part of the premaxilla; thus, the smaller section permitted a visualization of the premaxillary maxillary suture located between the cuspid and the third incisor. Both the large and the small parts of each maxilla were embedded in Selectron, a plastic material, the properties of which have been described by McLung.[38] Ground sections, 60 to 100 microns thick, were obtained with a

cutting-grinding machine adapted and designed for this purpose. The large block was cut in cross section to the maxillary midpalatal suture. In these sections the teeth were cut in a longitudinal manner. The smaller block containing the left cuspid was cut in cross section to this tooth.

In order to obtain an even thickness in each section, a uniform depression approximately 45 to 50 microns in depth was created on the surface of a stainless steel holder. Each section was placed in the depression and glued along its plastic edges to the holder with a drop of adhesive. The adhesive adhered firmly to stainless steel, was waterproof, and set within a few seconds. Each section, firmly in place, was then polished by a wet and dry technique, parts of which are described by Hammarlund-Essler.[41] The sections were left in water overnight; then they were removed and polished on the opposite surface. Finally, the sections were dehydrated in ascending grades of alcohol, cleared in xylol, and mounted in balsam for microscopic examination. Some of the sections were stained to provide a more visible contrast within the calcified areas and for photographic purposes. For these sections, Lillie's adaptation of von Kossa's stain[42] and a differential stain consisting of a mixture of safranine and fast green FCF[43] were used.

FINDINGS

The preceding section presented a detailed description of four experimental groups including three cats comprising a control group, two cats subjected to continuous expansion forces, two subjected to intermittent expansion forces, and two subjected to contraction forces. Each group was quantitatively and qualitatively studied through the use of dental casts, cephalometric headplates, and histologic sections.

In an effort to integrate more closely the results of cast and cephalometric study with the results of histologic analyses, a brief description of the gross and microscopic anatomy of the cat is presented within the text of this section. This is included for the purpose of facilitating a clear reference as to the location of specific sutures and thus aiding in the interpretation of histologic findings within the suture areas. To systematize presentation, the histologic findings for each of the areas studied will be grouped in accordance with the type of orthodontic force applied.

Quantitative Analysis of Tooth Movement as Determined From Casts.—The linear distance between the incisal tips of the maxillary cuspids was periodically measured in order to quantitate the amount of tooth movement. The intercuspid width was measured immediately prior to the insertion of the appliance, after three days of active treatment, and thereafter at weekly intervals. The results of these measurements are shown in Table I. All the cats were sacrificed by the ninth and tenth weeks of treatment.

The cats that were subjected to expansion forces showed an increase in intercuspid width ranging from 4.5 to 8.5 mm., as shown in Table I. Those subjected to continuous expansion forces showed a greater increase in this dimension (7 and 8.5 mm., respectively) than those subjected to intermittent expansion forces. In the latter group the increases in the width dimension were 4.5 and 5 mm., respectively.

TABLE I. AMOUNT OF TOOTH MOVEMENT

TYPE OF TREATMENT	INTER-CUSPIDAL WIDTH AT START OF EXPERIMENT (MM.)	INTERCUSPIDAL WIDTH DURING TREATMENT (MM.)											TOTAL INCREASE OR DECREASE (MM.)
		3 DAYS	FIRST WEEK	SECOND WEEK	THIRD WEEK	FOURTH WEEK	FIFTH WEEK	SIXTH WEEK	SEVENTH WEEK	EIGHTH WEEK	NINTH WEEK	TENTH WEEK	
Control	18	18	18	18	18	18	18.5	19	19	19	19	19	1
Control	19.5	19.5	19.5	19.5	19.5	19.5	19.5	20	20	20	20		0.5
Control	18	This cat was sacrificed at the beginning of the experiment											
Continuous expansion	16	17	17.5	18.5	18.5	18.5	21	19	23	22	24.5		8.5
Continuous expansion	17.5	18.5	19	20	20	20	21.5	22	22	22.5	24.5	24.5	7
Intermittent expansion	18	18	18	18	19	19.5	21	22	23	23	22.5		4.5
Intermittent expansion	19.5	20	20.5	20.5	21.5	21.8	22	23	22* then 23	23.5	23.5	24.5	5
Intermittent contraction	18	17	17	16	16	16	15	14	15				−3
Intermittent contraction	16	This cat was contracted, and used as part of a pilot study; it was sacrificed after three months											−2

*Upon repair of a broken appliance, there was an increase of 1 mm. in one hour.

The mean curves of tooth movement showed that under the influence of continuous expansion forces there were intermittent increases and decreases in the width dimension. This may be correlated with a gradual reduction in the effective expansive forces as the coil spring approached its original size and shape. The group subjected to intermittent expansion forces seemed to show a continuous increase in the width dimension.

The cats subjected to contraction forces exhibited a decrease of 2 and 3 mm. from the original intercuspid width (Table I). It should be noted that contraction of the maxillary arch of the cat beyond a certain limit seemed impossible. In occlusion the long maxillary cuspids occlude lateral to the mandibular cuspids (Fig. 3, *A*). One of the cats subjected to orthodontic contraction forces showed a steady decrease in weight and died during the seventh week of treatment. It was not possible to ascertain accurately the cause of death. The second cat survived the contraction treatment. Both animals manifested crowding in the anterior teeth of the lower arch (Fig. 3, *A*). This seemed to result from the constricting influence of the maxillary cuspids on the mandibular cuspids. An inadequate occlusal relationship between the upper and lower arches seemed to follow.

Cephalometric Analysis.—The superimpositions of the tracings of lateral headplates taken before and after orthodontic treatment indicated that there were no growth changes in any of the cats during the experimental procedures. The size and general contour of the cranium remained the same in the control group as well as in the experimental group. Superimposition of bony facial structures also revealed no growth changes in either group. However, the cephalometric appraisal of the maxillary skeletal and maxillary denture areas of the experimental animals did show changes which seemed to result from orthodontic treatment.

Superimpositioning on the hard palate contour, registering on the posterior nasal spine, did not reveal any difference in the relationship of the bony elements of the control group (Fig. 4, *A*). However, the same superimpositions in the experimental group did reveal changes in the relationship of parts. They seemed to indicate a slight change in the position of the premaxilla following orthodontic treatment. In relation to the palatal plane, the premaxilla of the animals subjected to expansion forces seemed slightly repositioned in a downward direction (Fig. 4, *B*). In the cat subjected to contraction forces, it seemed to be in a slightly elevated position (Fig. 4, *C*).

All tracings exhibited changes in tooth position at the end of the experiment. In the control group there was a general downward and backward repositioning of the maxillary cuspid (Fig. 4, *A*). This is interpreted as representing a normal adjustment in tooth position, perhaps correlated with the terminal phases of the eruption pattern of this tooth. As in the control group, the maxillary cuspid was also repositioned in a downward and backward direction in the expansion groups (Fig. 4, *B*), but this repositioning occurred to a greater degree. In the cat that was subjected to contraction forces, the cuspid was repositioned in an upward and forward direction after orthodontic treatment (Fig. 4, *C*).

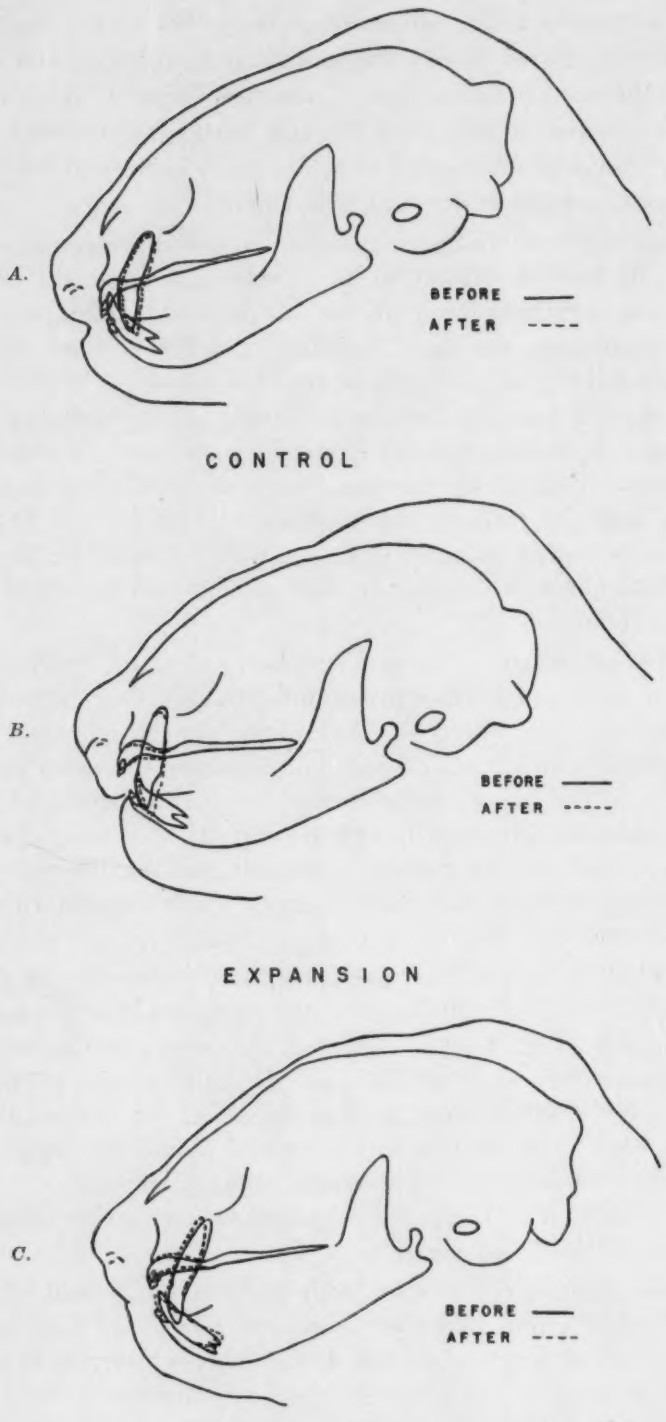

Fig. 4.—*A*, Superimposed tracings of lateral headplates of a cat of the control group. *B*, Superimposed tracings of lateral headplates of a cat subjected to orthodontic expansion forces.

C, Superimposed tracings of lateral headplates of a cat subjected to orthodontic contraction forces.

Gross Anatomy of the Maxillary Palate of the Cat.—The midpalatal suture of the cat is formed by three pairs of bones, united at the midline (Fig. 6). In the anterior region of the upper face the midpalatal suture is formed by the junction of the two premaxillae. Continuing posteriorly the suture is formed by the union of the two maxillary bones and is completed by the junction of the right and left palatine bones (Fig. 6). These three pairs of bones are united to each other by connective tissue fibers. The midpalatal suture itself is composed of the uniting connective tissue fibers.

In the palatal surface of the upper jaw two pairs of sutures, radiating from the midpalatal suture, are evident. Anteriorly, the suture formed by the junction of the premaxillary and maxillary bones runs in an outward and forward direction (Fig. 6). It then turns cephalad onto the lateral surface of the face and continues as the premaxillary maxillary facial suture to join with the nasal bone. The suture formed by the junction of the maxillary and palatine bones meets the midpalatine suture at a right angle and then runs in an outward and backward direction to join with the sphenoid bone (Fig. 6).

Each of the afore-mentioned sutures was examined histologically. Interpretations were based upon the study of decalcified as well as ground sections. The decalcified sections permitted a thorough visualization of cellular reactions, whereas the ground sections permitted a clearer analysis of the anatomic relationship of the bony parts surrounding the midpalatal suture.

Microscopic Anatomy of the Midpalatal Suture of the Cat.—

Histologic analysis of the premaxillary region: Serial cross sections of the anterior region of the hard palate of the control animals revealed that the two premaxillary bones are joined by connective tissue. The connective tissue binding, which constitutes part of the midpalatal suture, is loosely arranged in its configuration and runs in parallel strings of fibers throughout the length of the suture. The connective tissue is continuous with the mucous membrane of the oral surface and the nasal crest of the nasal surface. The main bulk of connective tissue fibers extends from the region of the anterior nasal spine to the maxillary bones. A few binding connective tissue fibrils extend at right angles from the main bulk of the connective tissue of the suture to unite with the midpalatal edges of the premaxillary bones. They represent the bony connective tissue attachment. A few blood capillaries and lymphatic vessels were seen scattered through the interpremaxillary suture.

In the control cats, the width of the midpalatal suture in the premaxillary area was found to range from 0.02 to 0.21 mm. (Table II, Fig. 5). There was no evidence of interdigitation of the bony edges of the suture. The palatal edges of the two premaxillary bones are parallel to each other with the connective tissue between them. Histologic examination revealed that the bony edges of the suture were in a resting stage. There were no apparent active cellular transformations on the sutural surface of the bones.

The oral mucous membrane covering the suture was highly vascularized with a normal scattering of connective tissue. The connective tissue was sparse

TABLE II. AVERAGE MINIMUM AND MAXIMUM WIDTHS OF CONNECTIVE-TISSUE ATTACHMENT

AREA OF EXAMINATION		CONTROL (MM.)	CONTROL (MM.)	CONTROL (MM.)	CONTINUOUS EXPANSION FORCES (MM.)	CONTINUOUS EXPANSION FORCES (MM.)	INTERMITTENT EXPANSION FORCES (MM.)	INTERMITTENT EXPANSION FORCES (MM.)	INTERMITTENT CONTRACTION FORCES (MM.)	INTERMITTENT CONTRACTION FORCES (MM.)
Periodontal membrane	Min.	0.14	0.14	0.15	0.14	0.10	0.10	0.07	0.07	0.10
	Max.	0.20	0.21	0.20	0.44	0.70	0.70	0.49	0.42	0.40
Premaxillary midpalatal suture	Min.	0.02	0.07	0.04	0.42	0.07	0.21	0.48	0.04	0.08
	Max.	0.21	0.14	0.16	0.70	0.53	0.53	0.78	0.07	0.10
Maxillary midpalatal suture	Min.	0.19	0.10	0.15	0.42	0.14	0.21	0.35	0.14	0.10
	Max.	0.28	0.21	0.24	0.48	0.35	0.48	0.70	0.21	0.25
Palatine midpalatal suture	Min.	0.10	0.05	0.07	0.10	0.10	0.10	0.05	0.10	0.09
	Max.	0.28	0.14	0.21	0.14	0.14	0.14	0.11	0.14	0.15
Premaxillary maxillary facial suture	Min.	0.02	0.10	0.06	0.14	0.14	0.14	0 02	0.07	0.05
	Max.	0.10	0.14	0.10	0.28	0.35	0.35	0.28	0.14	0.15
Premaxilary maxillary palatal suture	Min.	0.05	0.07	0.07	0.10	0.10	0.04	0.11	0.05	0.07
	Max.	0.11	0.14	0.14	0.15	0.12	0.11	0.14	0.20	0.11

in nuclear structure and rich in fibers. The nasal surface of the connective tissue of the suture was covered by a thick layer of fatty tissue embedded in a very thin band of loose connective tissue fibers. The cartilage of the nasal septum rested on these loose connective tissue fibers.

Histologic analysis of the maxillary midpalatal suture: In the control animals, the maxillary midpalatal suture was more complex in its structure than the premaxillary midpalatal suture. The two palatal processes of the maxillary bones were closely interdigitated throughout their entire length. The connective tissue which separated them followed the same interdigitative pattern. The threadlike fibrils which extended from the main bulk of connective tissue fibers to unite the two premaxillary bones were not visible in the area of the maxillary bones. The fibrillar attachment to the midpalatal edges of the two maxillary bones involved all the connective tissue fibers of the suture. These fibers had no definite pattern and ran in all directions. They were compact and densely packed. In the area of the maxillary bones the midpalatal suture ranged from 0.10 to 0.28 mm. in width (Table II, Fig. 5).

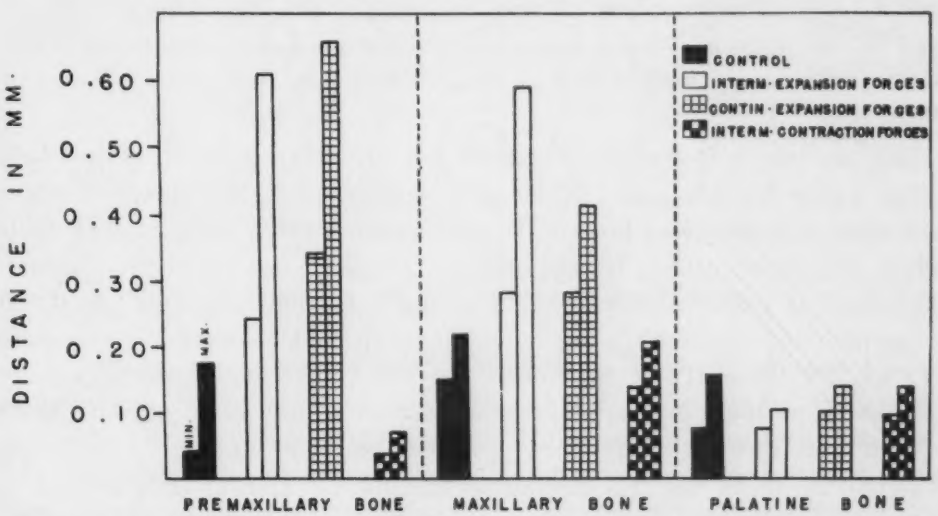

Fig. 5.—Mean minimum and maximum widths of the connective tissue attachment of the various bones forming the midpalatal suture under different types of orthodontic forces.

In the histologic sections, the vomerine bone was seen to rest on the nasal crest of the maxillary bone. Between the vomer and the nasal septum, as in the premaxillary area, a mass of loose fatty connective tissue was evident. The vomer assumed an oblique position in its relation to the midpalatal suture between the two maxillary bones and inserted more deeply into the suture as it approached the palatine bone.

Histologic analysis of the palatine midpalatal suture: Histologic sections of the midpalatal suture between the horizontal plates of the palatine bones of the control animals revealed a thick connective tissue binding. It appeared similar in its structure to the connective tissue uniting the two maxillary bones. The vomer inserts in the anterior third of this suture. This anatomic relationship permits the vomer to be in contact with the oral mucosa, completely dividing

the two palatine bones in this area. The posterior edge of the vomer extends upward toward the base of the cranium and is not in contact with the posterior two-thirds of the horizontal plates of the palatine bones. In this area, the superior surface of the horizontal plates is lined with the mucous membrane covering of the nasal cavity. It is rich in mucous glands and ciliated respiratory epithelium.

Histologic analysis of changes in the midpalatal suture of the cats subjected to continuous expansion forces:

Changes in the premaxillary area. Under the influence of continuous orthodontic forces, the midpalatal suture in the premaxillary area appeared to be clearly opened. This opening, which was not observed in the control group, ranged from 0.34 to 0.66 mm. in width (Table II, Fig. 5). Histologic examination of the decalcified sections revealed a great number of disconnected connective tissue fibers in the suture area. There was an increase in fibroblastic activity, and in many sections the nuclear chromatin was seen in an active stage of cariosinesis. This increase in the size of the nucleus occurred at the expense of cytoplasm, which appeared proportionately diminished. The fibroblasts were closely packed and in contact with the free edges of the premaxillary bone.

Along the bony edges of the suture, a fine hematoxylin band was evident, indicating a new deposition of calcium salts. Furthermore, the fibroblastic cells had lost their processes, had become larger, and were being encapsulated while changing into bone cells. In the ground sections, the preosseous formation appeared as a fine silvery dust. The newly formed bone was laid down in a perpendicular relationship to the matrix of the old bone, and it was more fibrillar in structure. These fibers had the same direction as the expansion forces. The new bone formation was not always symmetrical on both sides of the suture; more was evident on one side than on the other.

The epithelium of the oral mucous membrane was thicker than normal in certain areas and decreased in other areas. The connective tissue of the mucosa was lacerated throughout its structure and disorganized. Evidence of an edema was also seen in the suture area. The connective tissue covering the nasal surface was thickened and in certain areas there was an absence of the fatty tissue between the cartilage of the nasal septum and the nasal crest of the premaxillary bones.

Changes in the Midpalatal Suture in the Maxillary Area.—Examination of the histologic sections of the animals subjected to continuous expansion forces revealed an opening of the anterior third of the maxillary midpalatal suture. As in the premaxillary area, the opening of the maxillary midpalatal suture was followed with the formation of new bone. Serial sections of the entire maxillary bone seemed to indicate that the posterior two-thirds of this area was less affected, since the opening of the suture seemed to taper as it passed posteriorly (Fig. 6). As the maxillary bones approached the palatine bones

the suture did not seem to be affected by the expansion forces. Where the suture was open, measurement of the midpalatal suture revealed widths as high as 0.48 mm. (Table II, Fig. 5).

In the anterior third of the maxillary midpalatal suture, where the separation of the two maxillary bones was most pronounced, the inferior tip of the vomerine bone was found within the suture. In this region new bone had been deposited along the edges of the palatal plates. The two sides of the vomer in contact with the maxillary bones also showed evidence of new bone formation with trabeculae following the direction of the expansion forces.

As in the premaxillary area, the connective tissue of the oral mucosa was lacerated and evidence of an edema was present.

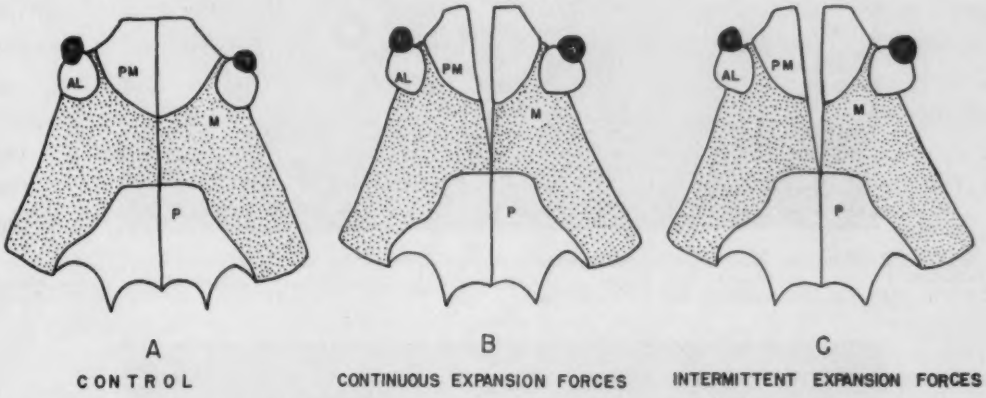

Fig. 6.—Diagrammatic illustrations of the various openings of the midpalatal suture under the influence of continuous and intermittent expansion forces. *AL*, Alveolar bone; *PM*, premaxilla; *M*, maxilla; *P*, palatine bone.

Changes in the midpalatal suture in the area of the palatine bones. Under the influence of expansion forces, of both the continuous and the intermittent type, the posterior two-thirds of the palatine midpalatal suture was in a stage of complete calcification through half its vertical height; that is, the area in contact with the oral mucosa. In this region the connective tissue forming the suture was in a stage of reorganization. The fibroblasts were large and intensely basophilic. Their normally oval-shaped nuclei became more round in appearance and were localized at one pole of the cell. A formation of preosseous bone was evident in this area, but it appeared to be different from the new bone found in the area of the premaxillary and maxillary bones. It was homogenous in structure, with no definite pattern, and similar to the trabeculae within the rest of the palatine bone. The rest of the suture was similar to that seen in the control group.

Histologic analysis of changes in the midpalatal suture of the cats subjected to intermittent expansion forces:

Changes in the premaxillary area. The premaxillary midpalatal suture of the cats subjected to expansion under the influence of intermittent orthodontic forces was the same histologically as that observed in the group of cats subjected

to continuous expansion forces. The suture appeared to be clearly opened (Fig. 7), with the suture width in these animals ranging from 0.24 to 0.61 mm. (Table II, Fig. 5). Once again the connective tissue appeared disorganized

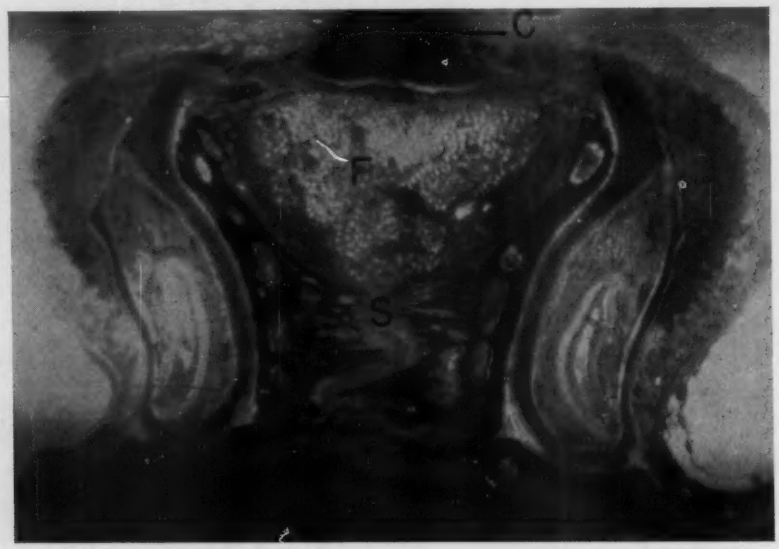

Fig. 7.—Ground section through premaxillary area of a cat subjected to intermittent expansion forces. Note relation of pad of fat to cartilage of nasal septum and the opening of the suture. *S*, Suture; *F*, fat; *C*, cartilage.

Fig. 8.—A cross section of the maxillary suture of a cat subjected to intermittent expansion forces. Note the opening of the suture, the stretching of the connective tissue fibers, and the new deposition of bone along the maxillary edges. *S*, Suture; *OB*, old bone; *NB*, new bone.

with evidence of fibroblastic activity and cellular multiplication. A distinct deposition of new bone, perpendicular to the old trabeculae of the palatal parts of the premaxillary bones, was concomitantly evident. Remnants of blood clots were also evident among the connective tissue elements. They were

scattered throughout the suture area and appeared to be in a stage of reorganization. In the area adjacent to the nasal cavity these blood clot remnants seemed to be organizing into new bone. In certain areas the pad of fat inferior to the nasal cartilage was absent and the nasal cartilage was in close contact with the nasal crest of the premaxillary bones. This was also evident in the animals subjected to continuous expansion forces.

Changes in the Area of the Maxillary Bones.—Under the influence of intermittent expansion forces, a wider opening of the maxillary suture was evident in this group than in the group subjected to continuous expansion forces (Fig. 8). In these animals the width of the midpalatal suture ranged from 0.21 to 0.70 mm. (Table II, Fig. 5). Once again the opening of the suture was followed by the deposition of new bone along the palatal edges. The deposition of new bone along the inferior edges of the vomerine bone was also evident and was similar to that seen in the animals subjected to continuous expansion forces.

Remnants of the blood clot which were present in the premaxillary area of the animals subjected to intermittent expansion forces were also seen in the area of the maxillary bones. The fatty connective tissue evident in the control group between the vomerine bone and the nasal cartilage was not always present in these experimental animals.

Histologic analysis of changes in the midpalatal suture of the cats subjected to intermittent contraction forces: In the cat subjected to contraction under the influence of intermittent orthodontic forces, the two edges of the premaxillary bones were seen in close contact. The sutural width ranged from 0.04 to 0.07 mm. (Table II, Fig. 5). The connective tissue fibers forming the suture appeared to be squeezed between the two premaxillary bones. The cartilage of the nasal septum and the fatty tissue did not seem to be affected in their positions when compared to the control group.

In the area of the maxillary bones the width of the midpalatal suture closely approximated that of the control animals (Table II). In some sections the palatal plates of the two maxillary bones were in close approximation to each other but were not fused. A deviation of the nasal septum and supporting vomerine bone was evident (Fig. 9). Toward the deviation side, the vomer was in close contact with the lateral crus of the alar cartilage. At the area of contact the alar cartilage was in a state of ossification as revealed by von Kossa's stain. There was a slight decrease in its diameter as compared with the opposite alar cartilage, which was larger and remained cartilaginous in structure (Fig. 9). These anatomic relations were detected in a ground section across the maxilla.

In the animals which were subjected to contraction forces there was no difference in the configurative anatomy of the palatine midpalatal suture when compared to the control group. There was no evidence of compression or ossification. In all the experimental animals the midpalatal suture seemed to be least affected in the area of the palatine bones.

Changes in the premaxillary maxillary palatal suture and the premaxillary maxillary facial suture. Since changes under the influence of orthodontic forces

were evident in the midpalatal suture, it was decided to see if concomitant changes occurred in one of the adjacent sutures. The suture separating the palatal plates of the premaxillary and maxillary bones and extending laterally from the midpalatal suture was examined (Fig. 6). This suture, as it extends laterally, passes anterior to the periodontal membrane of the maxillary cuspid and then turns onto the facial surface, continuing in an upward and backward direction to meet the nasal bone. The facial aspect of this suture was also examined.

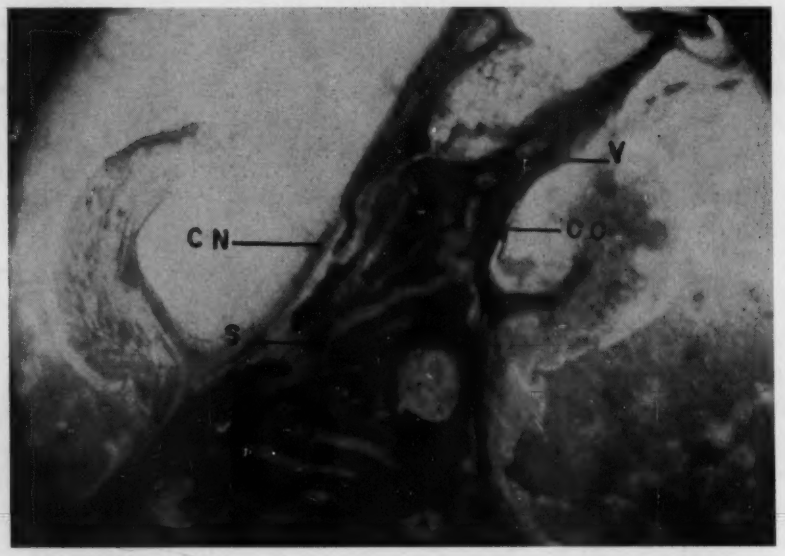

Fig. 9.—Ground section through the maxillary area of a cat subjected to intermittent contraction forces. The section is stained with von Kossa's stain and shows the extent of calcification. Note the deviated vomer and the calcification of the cartilage close to it. The cartilage of the opposite side is wider and remained unstained. *V*, Vomer; *CC*, calcified cartilage; *CN*, nonstained cartilage; *S*, suture.

Examination of the histologic sections of the premaxillary maxillary facial suture of the control group revealed that this suture is similar in structure to the midpalatal suture between the premaxillary bones.

Under the influence of expansion forces of the continuous type there was an active reproduction of cell units, with a subsequent deposition of new bone of the fibrillar type in the facial portion of this suture. The fibers of the newly formed bone were found to run parallel to the direction of the expansion forces and perpendicular to the old bone. Serial sections revealed, however, a lesser opening of the suture close to the nasal bone. Serial sections revealed also that there was no opening of the palatal portion of the premaxillary suture.

Under the influence of expansion by intermittent forces there were variations within the group. In one of the cats no difference was seen in both the facial and palatal aspects of the premaxillary maxillary suture when compared to the normal group. The reaction in the other cat was similar to the reaction observed in the group subjected to continuous expansion forces. In the cat submitted to contraction by intermittent forces, the reaction was not the same

throughout the premaxillary maxillary suture. The palatal aspect of the premaxillary maxillary suture exhibited new deposition of bone identical to that seen in the continuous expansion group. The deposition of new bone, however, was restricted to the medial fifth of this suture. The rest of the palatal aspect of this suture was closed. This seemed to indicate a closing of the suture laterally and an opening of the suture medially. A closure was also evident throughout the length of the facial aspect of this suture (Fig. 10). There was evidence of areas of contact of the two bones with a crushing of the connective tissue which separates them.

Fig. 10.—Cross section perpendicular to the long axis of the cuspid tooth of a cat subjected to intermittent contraction forces. The section shows the closure of the premaxillary maxillary facial suture. Notice the resorption of the tooth structure on the mesial aspect of the cuspid and crushing of the suture. *C*, Cuspid; *S*, suture; *PM*, periodontal membrane.

Changes in the periodontal membrane of the maxillary cuspid: Cross sections of the left maxillary cuspid and longitudinal sections of the right maxillary cuspid were examined. In the control animals histologic sections revealed that the cuspid tooth is evenly surrounded by periodontal fibers which firmly attach the tooth to the surrounding alveolar bone. The trabeculae of the surrounding alveolar bone were moderately thick, and large marrow spaces were present. The periodontal membrane was highly vascularized, with a physiologic width of 0.14 to 0.20 mm. The measurements of periodontal membrane width for each experimental group are presented in Table II.

In one of the cats subjected to continuous expansion forces, there was an increase in the width of the periodontal membrane followed by a deposition of new bone on the tension side. However, the tension side was not evenly filled with new bone. The newly formed trabeculae were partially undergoing resorption, as evidenced by the presence of Howship's lacunae filled with osteoclasts.

There was a concomitant decrease in the width of the periodontal membrane on the pressure side. On the pressure side the periodontal membrane and the alveolar bone were degenerating and had lost their cellular structure. In the alveolar bone this degenerative process was characterized by a local loss of osteocytes. In some sections there appeared to be a loss of continuity of the alveolar plate, and the oral mucosa had fused with the periodontal membrane. In other sections there was some evidence of bone formation on the outer aspect of the alveolar bone with an infiltration of granular tissue from the periosteal surface of the necrotic bone.

Close to the cuspid on the pressure side, Heidenhain staining of the alveolar bone revealed a fine, darker band of stain indicating chemical changes within the organic matrix. This differential stain seemed to indicate removal of calcium salts prior to removal of the supporting matrix. These manifestations were confined to the sections below the cementoenamel junction where the application of force seemed greatest. There was no evidence of resorption of tooth structure.

The reactions in the other cat in the continuous expansion group were somewhat contradictory, inasmuch as the behavior of the tooth structure and that of the alveolar bone on the pressure side were different. The ground sections, cut perpendicular to the long axis of the root, revealed an active resorption of tooth structure on the pressure side rather than change in the continuity of the alveolar plate close to it. Thus, a normal cellular activity was evident in the alveolar bone, whereas under pressure an active resorption on the root surface was evident.

Under the influence of expansion by means of intermittent forces, there was evidence of an excessive number of osteoclasts in the periodontal membrane on the pressure side. These giant cells were located at the edges of the alveolar bone and cementum of the tooth, both of which were excessively resorbed. Longitudinal sections of both decalcified and nondecalcified structures indicated again that the force was greatest at the level of the cementoenamel junction of the tooth.

Examination of the histologic sections revealed that in general the tooth movement was a tipping movement. This was confirmed by root resorption above the apex of the lingual aspect of the tooth and the presence of osteoclasts in the alveolar bone close to it. Yet, in all cases both tooth and bone structure were kept at a certain distance from each other by an even thickness of periodontal membrane.

The deposition of new bone under tension and the resorption of bone under pressure were also seen in the cats subjected to contraction forces. In these animals the deposition of new bone was on the labial alveolar plate rather than the lingual alveolar plate, since the direction of force was opposite to that applied in the expansion group.

DISCUSSION

The results of this study, in which cats were used as experimental animals, have provided evidence which supports the opinion that orthodontic expansion

forces applied in the maxillary region are capable of opening the midpalatal suture. Histologic analyses reveal that the cats subjected to continuous and intermittent orthodontic expansion forces showed an opening of the midpalatal suture and a concomitant deposition of new bone. The observation that opening of the midpalatal suture occurred must be qualified by the statement that the degree of opening was limited and was not uniform throughout the extent of this suture (Fig. 6). It was apparent that the midpalatal suture was opened to a greater degree in the area of the premaxillary bones than in the area of the maxillary bones. No opening was evident in the more posterior regions of the palatine bones.

The greatest degree of opening was found in the interpremaxillary suture (Fig. 6), in spite of the fact that the orthodontic forces were applied directly to the cuspids which are firmly implanted in the maxillary bones. A plausible explanation for this may be suggested by pointing up the variations in the connective tissue attachments of the three bones of the hard palate which were observed.

In the premaxillary area the connective tissue of the midpalatal suture is loosely arranged. The sutural attachment proper consists of tiny fibrils which extend from the main bulk of this loose connective tissue to the bony edges of the suture. As reported, the main bulk of connective tissue tends to run parallel to the suture. This arrangement was not evident in the maxillary midpalatal suture. The connective tissue attachment between the two maxillary bones (Fig. 8) and between the two palatine bones is thicker, stronger, and more firmly attached to the bones. This seems to result from connective tissue fibers which course in a more perpendicular relationship to the suture and appear to attach one bony margin of the suture to the other. The looser connective tissue attachment in the suture of the premaxillary area may have offered less resistance to the expansion forces than that offered in the maxillary and palatine bone areas.

In addition to variation in the respective connective tissues of the premaxillary, maxillary, and palatine areas of the suture, variations in the configuration of the bony margins of the suture were also observed. The bony configuration of the midpalatal edges of the maxillary bones, in itself, may have been instrumental in preventing a greater degree of opening. The palatal processes of the maxillary bones are closely interdigitated, whereas the edges of the premaxillary bones run parallel to each other. Because of this difference in the bony margins of the suture, a comparatively greater degree of force may have been required to open the maxillary midpalatine suture than was needed for opening the interpremaxillary suture.

It is also possible that the variation in the degree of opening of the midpalatal suture between the three pairs of bones forming the hard palate may have resulted from an uneven distribution of forces. Lateral forces were applied in the anterior region of the maxilla and may have caused a greater opening in this area than that observed in the palatine midpalatal suture, which was ossified in its inferior half, or in that area in close contact with the oral mucosa.

The deposition of new bone in the suture area indicates that growth within the suture may be influenced, to a degree, by mechanical factors. This growth may be independent of the growth potential of the bones themselves. As stated, the animals utilized in this study were fully grown cats. That growth of the face and the cranium did not occur during the experimental procedures was substantiated by the superimpositioning of the cephalometric tracings of headplates obtained before and after orthodontic expansion. Therefore, it may be assumed that the deposition of new bone in the midpalatal suture resulted from the influence of orthodontic expansion forces.

The newly formed bone in the suture was of the bundle type and was different from the adjacent bone. It was also clearly differentiated from the older bone. This sutural reaction resulting in the formation of new bone is similar to the histologic reaction observed in the periodontal membrane and alveolus when force is applied to contiguous dental units. There is abundant evidence that bone is usually deposited on the tension side of the periodontal membrane under the influence of orthodontic forces. The analogous reactions in the suture and dentoalveolar areas suggest that the connective tissue of the suture is similar to the periodontal membrane surrounding the teeth. Both connective tissues are composed of the same elements and appear to respond to the mechanical application of forces in a similar manner. It is suggested that these stretched fibers, attached to the bony margins of contiguous bones, stimulated the deposition of bone.

All of the cats subjected to orthodontic expansion forces presented evidence of traumatic injury subsequent to the opening of the midpalatal suture. Histologic evidence for this occurrence was particularly prevalent in the oral mucous membranes of the cats. There were manifestations of disorganized connective tissue and edematous infiltration. These mechanisms are defensive in nature and are due to a dilatation of the blood vessels and a stretching of the connective tissue fibers.

Examination of the casts made it evident that tooth movement within the alveolar process accounts for a greater amount of increase in width than suture changes. In some of the cats the cuspid teeth and surrounding alveolar bone were extending laterally away from the contour of the maxillary dental and alveolar arch. These teeth were literally moved out of the arch (Fig. 3, *B*).

This extreme adjustment of cuspid teeth, coupled with the traumatic reactions described, serves to indicate that the expansive force in the experimental animal was nonphysiologic. The physiologic orthodontic force for man, which determined the degree of force applied in this study, may be an excessive force for the cat. The results support this possibility and suggest that the amount of expansion or the degree of force, or both, were excessive in the case of the experimental animals used. Weaker forces might not have produced evidence of trauma, but by the same token weaker forces might have had little or no influence on the suture area. It may be that the midpalatal suture can be opened only under the influence of strong forces.

These considerations emphasize the need for more research to substantiate or refute this possibility. More specifically stated, an extension study of this type, designed to define cephalometrically and histologically the results of orthodontic expansion utilizing varying degrees of expansion forces, seems indicated. Even though gradation of forces was not included in the present study, the results of varying types of force do suggest that if the suture can be opened with the application of physiologic orthodontic forces there must be a limitation to the extent to which it can be opened without concomitant undesirable effects.

Since there is a scarcity of definitive histologic information relative to the midpalatal suture areas in man, there exists a weak comparative basis for generalization. Clinical inferences stemming from the results of study of any experimental animal must be cautiously drawn. However, the composite results of this study do not permit the unequivocal generalization that there can be no sutural response in orthodontic expansion. The results of this investigation indicate, furthermore, that sutural reaction to orthodontic expansion in the cat was not limited to the opening of the midpalatal suture alone. There were concomitant effects on the contiguous maxillary sutures. An opening of the premaxillary maxillary facial suture was evident, while the palatal aspect of this suture was not affected similarly.

In addition to sutural changes associated with orthodontic forces, cephalometric analysis showed that there was a dislocation of the premaxillary bones under the influence of the forces. In both the expansion and the contraction experimental procedures, the spatial position of the premaxillary area of the cat was altered, whereas other structures of the maxillary facial complex remained stable in their respective positions. The premaxillae appeared to be tipped in either a superior or an inferior direction, depending upon the type of force applied. The actual movement of this segment may have placed tension on the connective tissue fibers within the facial suture, initiating the deposition of new bone.

One of the cats subjected to expansion forces showed this deposition of new bone in the facial suture and also exhibited areas of bone resorption extending from the premaxillary maxillary facial suture to the periodontal membrane at the distal aspect of the maxillary cuspid. Osteoclasts were seen lodged within bony depressions, indicating a homologous resorption process. It can be stated that there is a certain growth potential within the bony elements to accommodate the parts and that beyond these limits resorption is inevitable.

In considering the results of expansion in accordance with the type of force applied (continuous or intermittent), it is emphasized that there was a distinct difference in the size of the opening of the midpalatal suture under the influence of continuous as opposed to intermittent expansion forces. The results show that the opening was greater when intermittent expansion forces were applied (Fig. 6). Yet in this group the amount of tooth movement was considerably smaller than in the other group. These findings indicate that

there was a significant difference in the area and extent of response to orthodontic expansion as a function of the type of expansion force applied. In the animals subjected to intermittent expansion forces it seems possible that the force applied to the teeth was too strong to produce an immediate response in the dentoalveolar area and was transmitted through the bone to the suture area. At the suture the force may have been more moderate, and this may have stimulated the tissue response. Once the cellular activity started in the suture, it proceeded with the subsequent application of forces. The periodic application of these strong intermittent forces resulted in a traumatic separation of the two palatal plates. This suggests that the dentoalveolar area may be more resistive to the sudden application of force than was the suture area.

In the cats subjected to continuous expansion forces there was a more gradual application of force. Perhaps this resulted in an initial response in the periodontal membrane area, followed by a response in the premaxillary maxillary facial suture area and, after a period of time, in the midpalatal suture area. This sequence of occurrences could explain the excessive response evident in the periodontal membrane area under the influence of continuous expansion forces. A more normal response in this area was evident in the intermittent expansion group.

The reactions associated with tooth movement which are characterized by the deposition of bone on the tension side and resorption of bone on the pressure side were consistent for each experimental group studied. These findings support the general concepts already established pertaining to tooth movement. However, the giant multinucleated cells, present simultaneously with the new bone deposited on the tension side of the teeth of cats subjected to continuous expansion forces, are somewhat contradictory. If osteoclasts are responsible for bone resorption, this reaction would appear to indicate a removal of bone upon its formation.

In accordance with these observations, it seems feasible to assume that the forces applied on the tooth were not within the limits of tolerance. This assumption is supported by Weinmann and Sicher's[44] statement that "too great a force upon a tooth leads to bone resorption on the tension side." Further support for this is afforded by the fact that on the pressure side of the same tooth there were a necrosis of the alveolar plate and halisteresis, both of which are indicative of excessive pressure.

The necrosis of the alveolar bone and its simultaneous removal indicate that the alveolar plate does not necessarily keep pace with the tooth movement under strenuous conditions. As a sequela, teeth may be extruded into the oral mucosa, as was reported in this study.

The strong tendency of the tooth to return rapidly to its original position, once the appliance had been removed or broken, indicates that the position of the cuspid teeth following expansion or contraction was not stable. After the removal of expansion forces, the cuspid teeth were subject to the effects of external, unbalanced muscular forces. Whether a long retention would help retain this unphysiologic repositioning of the maxillary bones and teeth and

whether muscular readaptation and bony remodeling of the osteoid tissue of the suture would occur is not known. It is hoped tht this will be the subject of future investigation.

These results seem particularly significant since they offer experimental evidence of a definite character, which is descriptive of change resulting from excessive orthodontic force. The results are also suggestive of significant differentials resulting from different types of expansive orthodontic forces. Although the degree of force was not specifically quantified, the results suggest that future investigations of other types of orthodontic forces, controlled with regard to type and degree, may be fruitfully pursued in a similar manner with experimental animals.

SUMMARY AND CONCLUSIONS

Different types of orthodontic forces were applied directly on the maxillary cuspid teeth of fully grown cats in order to study the effect of those forces on the maxillary midpalatal suture. In this investigation nine cats were studied. They were divided into four groups. The three cats in the control group were not subjected to any orthodontic forces. The other three groups, each composed of two cats, were respectively subjected to intermittent expansion forces, continuous expansion forces, and intermittent contraction forces.

Cephalometric roentgenograms, dental casts, and histologic sections consisting of decalcified and nondecalcified sections were used to evaluate objectively the maxillofacial and sutural changes associated with the application of these forces. In both the expansion and the contraction groups, the superimposed cephalometric tracings showed no growth changes during the period of treatment. Cephalometric tracings superimposed on the palatal contour indicated a tipping of the premaxillary bone following orthodontic expansion and contraction. The premaxillae were tipped in a downward and backward direction in the cats subjected to expansion forces and they were tipped in an upward and backward direction in the cats subjected to contraction forces.

Following the application of orthodontic expansion forces, the maxillary midpalatal suture was opened. The degree of opening was not the same throughout the length of the suture. The premaxillary midpalatal suture was opened to a greater degree than the maxillary midpalatal suture. The suture was not opened in the area of the palatine bones. There was a concomitant opening in some areas of the surrounding sutures.

The opening of the midpalatal suture was accompanied by a formation of new bone at both edges of the two palatal plates bordering the suture. This new bone formation, which was of the bundle type, was not symmetrically deposited on both edges of the suture. It is hypothesized that the stretching of the connective tissue fibers of the suture stimulated the deposition of new bone. It seemed analogous to the deposition of new bone on the tension side of the periodontal membrane following tooth movement under the influence of orthodontic forces.

Concomitant with the opening of the midpalatal suture, there was evidence of traumatic injury characterized by dilatation of the blood vessels, as well as

edema with evidence of disorganized connective tissue in the palatal mucosa and the midpalatal suture. It is suggested that the degree of force or the amount of expansion, or both, was excessive in the case of the experimental animals used. In both the expansion and contraction groups, tooth movement was correlated with a new deposition of bone on the tension side and a resorption of bone on the pressure side. If the force applied upon the tooth is excessive, a necrosis and a subsequent removal of the alveolar plate results on the pressure side. In general, associated with these reactions, there is a resorption of tooth structure on the pressure side. On the tension side, under the influence of excessive forces, an osteoclastic resorption is concomitant to the deposition of new bone.

The results of this study suggest that future investigation in these areas might be fruitfully pursued. Further studies are required so that findings may be conclusively applied to orthodontic treatment procedures in human beings.

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THE RESPONSIBILITIES OF THE DENTAL SPECIALTIES

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FIRST, I want to thank Frank Bowyer for his kind introduction and next I want to express my sincere appreciation upon being invited to speak before this group today. While it is my good fortune to know most of you personally, and while I think that most of us share the same basic philosophy concerning our responsibilities, I do want to take just a few minutes to re-emphasize some things that we are professionally and morally obligated to do.

During the past six years I have crisscrossed the United States many times and have had ample opportunity to hear the dental profession's good and bad points discussed. I am very pleased to report that the good far outweighs the bad. However, we should not become complacent.

I wonder how many of us who limit our practice to one of the seven recognized specialties of dentistry realize how much criticism we are receiving from the public and from general practitioners of dentistry? Perhaps it would be well for each one of us to stop and analyze himself a little bit closer. We should remember that we are American citizens first and dentists second, and that although we may be specialists, instructors in school, workers in research, etc., we are still basically members of the dental profession.

Our relations with the public can be improved by convincing the public that we are an integral part of the total health picture. While dental specialists, as a rule, do not have the opportunity to become "family" dentists, they can assist the family dentists in educational procedures regarding dental health. Someone has wisely said, "The best wealth is health."

Our public relations with the general practitioners of dentistry—our brother dentists—can be improved. Even though I am biased, and understandably so, I honestly believe that the overwhelming majority of dental specialists are making a sincere effort to serve the public, the dental profession, and their particular specialty in an excellent manner. Surveys taken by the American Dental Association show that dental specialists receive more financial remuneration for their services than do other members of the dental profession. Many general practitioners feel that specialists work only about three or four hours a day. (This charge is made against orthodontists particularly.) You and I know that this belief is not true, but why do we hear it?

One of the obligations of our profession is to recognize our weak points as well as our good ones and to set about correcting our weak points, just as we wish to emphasize our good points.

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*President-elect of the American Dental Association.

What is the purpose of having specialties? Is it not to provide the public and the profession with dentists trained a little bit longer and with more experience in certain fields so as to take care of the unusual and more difficult abnormalities of nature, the results of accidents, or the results of habits? In brief, it is the aim of the specialists to be available for consultation and to treat cases with knowledge, skill, and experience not required in the routine procedures of general practice. If we can accept this necessity for a specialist, then we must admit that our responsibilities are toward the public and other professional health personnel.

All of our specialties have made great progress during the past few years, both in scientific knowledge and in recognition by the public and by health personnel. By increasing our horizons rather than being complacent or narrowing our perspectives, we can show to all concerned that we are worthy of this recognition which our profession and our specialties enjoy.

As a member of the American Association of Orthodontists and as president-elect of the American Dental Association, I am very pleased that the American Association of Orthodontists rescinded its previous action of this year and made membership available to qualified applicants by formal training requirements and also by controlled and approved associateship requirements.

We must understand that general practitioners, as a rule, have less public recognition, as well as a lower income, than is accorded specialists. Dental students today are talking well in advance of graduation about becoming specialists. This attitude of becoming a specialist also prevails in the minds of many of our practitioners who have practiced general dentistry for several years and have now decided that they wish to take up a specialty. What about these men? In only nine states is it legally impossible for a dentist to represent himself as practicing one of the dental specialties, with or without training. However, the vast majority of our brother dentists realize their moral responsibility and their professional responsibility and wish to receive training so that they can perform a better service by virtue of having had the additional training and experience.

With absolutely no criticism directed toward the dental schools, I think that all of us realize that our schools can accept only a small percentage of the applicants desiring to study a specialty. Failing to get into dental school, the applicants have no choice but to become associated with a reputable specialist for a specified length of time or else to attempt cases and just hope for the best. I am not opposed to formal training for any of the specialties, but I know that we have adequate facilities in our dental schools for but a very few of our applicants to take formal training. Therefore, in my understanding of the situation, I am absolutely opposed to any specialty making requirements for membership or for board certification that are totally unrealistic with respect to our responsibilities as a major health profession.

The primary responsibility of a dental school is to train students to practice dentistry. Where time, faculty, finances, and facilities permit, I believe that we all would encourage postgraduate and graduate courses.

I want to compliment the orthodontic specialty for being the first recognized specialty of the dental profession to have a certification board. I have studied the records of this board quite closely and find that it has done an excellent job with regard to requirements and in percentage of approval and rejection. I believe that this board has the respect of the vast majority of the orthodontists of the United States as well as the general practitioners of dentistry. I am sorry that I cannot be that complimentary about all dental specialty boards, but I hope and believe that progress will be made in this respect in the near future.

One of our great weaknesses as orthodontists is that some of us are failing to recognize the fact that the American public today is on the move more than ever before. All of us in orthodontics know that we are having more and more transfer patients and that this often leads to problems which call for a serious consideration of our public relations among ourselves, with our general practitioners of dentistry, and with the public.

Some of us do not keep adequate case records. Some of us do not use the methods of treatment and the types of appliances that others of us like. Some of us make statements sometimes that are frankly unethical. One of our greatest faults with regard to transfer cases is the fact that some of us do not refer our patients to another orthodontist directly but just let the patient and his parents flounder. We have a moral obligation that extends far beyond the time that the patient is under our individual care.

If we give the patient the records that we have pertaining to his individual case and tell him to find an orthodontist in the area to which he is moving, without our contacting an orthodontist to see if he can continue the case (not necessarily with the same type of appliance that we have, but utilizing the type of appliance and method of treatment that he feels can secure the best and most lasting results), and this patient actually finds someone who performs a good service, then neither the patient nor the new orthodontist feels any sense of obligation to the previous orthodontist.

However, if we direct this patient to a specified orthodontist in the area, after having made the necessary contact, then all concerned can cooperate for the best interest of the patient. We receive no public relations credit if the patient accidentally finds a good orthodontist to carry on treatments; we suffer if our patient accidentally gets into the hands of someone incapable of proper treatment. Direct reference is always the best procedure.

Time does not permit me to discuss all of the matters pertinent to specialties, but I do want to call your attention to the fact that a glance at the roster of the House of Delegates of the American Dental Association, not only this year but each year, reveals that many of these delegates and alternate delegates are members of the orthodontic specialty. This is good. Other specialties are well represented, too. Yet, some specialists do not attend their local, district, state, or national dental conventions because "the orthodontic program is so weak" or "the periodontic or oral surgery, etc., program is so weak."

Now let us be honest with ourselves and admit that we cannot have—nor do we want—heavy specialty programs at the American Dental Association convention, for time and demand do not permit this type of program and the American Dental Association is not in competition with the specialties.

I think that all of you have heard Martin Fisher's saying that "the specialist is too commonly hypertrophied in one direction and atrophied in all the rest." By our attendance at local, district, state, and national dental conventions, we can demonstrate that this is not true with regard to the dental specialists.

Many members of the Southern Society of Orthodontists have furnished splendid leadership, not only in orthodontic affairs but in American Dental Association affairs as well. (Incidentally, as you know, three members of the A. D. A. Board of Trustees—Drs. Abel, Jones, and Patton—are orthodontists.)

What about the future of dentistry? In my opinion, it is brighter than ever before.

We have forty-six dental schools graduating 3,200 dentists annually. We have 86,000 practicing dentists, with 76,000 as members of the American Dental Association (the highest per cent of any professional group). The American Dental Association has 160 full-time and eighteen part-time employees. We own our own headquarters building in Chicago. We have fifty-four constituent societies and 450 component societies. We have an annual budget in excess of $2,500,000.00. We have more active educational programs concerning dental health than ever before.

We have more research, legislative, advisory, consultant, educational, and liaison activities than ever before. We are stressing preventive care as well as corrective care for the American public.

Yet, with almost 4,000,000 babies being born each year and with the loss of 1,500 to 1,800 dentists annually by retirement and death, we are not able to keep up with the present dentist-population ratio, which is 1:1,900. Dental ills, being as widespread as they are, deserve more and more dental research.

We have not begun to develop the potentials of the dental health field. More needs to be done regarding children's dentistry; more and better dentistry should be provided for inmates of mental institutions, hospitals, and penal institutions; we need more and better dentistry for deaf, blind, and crippled children; and certainly we need more and better dental care for cleft palate patients.

In short, we must realize that all members of our dental specialties are members of the dental health team and, as such, we have a professional and moral responsibility toward the organization that is our spokesman in Congress (in peace as well as in time of war); we have a professional and moral responsibility toward the organization that has represented and will continue to represent all dentists on all levels according to the policies of the American Dental Association.

Dentistry has a wonderful tradition and a splendid heritage. It provides each one of us with opportunities to serve humanity better than ever before.

Editorial

DOUBT AND CERTAINTY IN ROENTGENOGRAPHIC CEPHALOMETRICS

THE Workshop on Roentgenographic Cephalometrics sponsored by the American Association of Orthodontists was held at the Bolton Fund Headquarters, Western Reserve University, Cleveland, Ohio, on March 24, 25, and 26, 1957. A report on the workshop will be presented to the Association at the New York meeting this spring. The Board of Directors of the Association will be asked at that time to determine how the transcript of the workshop itself is to be made available to the membership and to orthodontists throughout the world.

Roentgenographic cephalometrics is a logical stage in the development of the art and science of orthodontics. Because the practicing orthodontist deals with problems of morphologic deviation his therapeutic approach must, of necessity, be based on an accepted norm or a series of norms. In the attempt to apply Angle's static classification of malocclusion to the dynamic dentofacial complex of the growing child, orthodontists found that they had to reckon with growth and development.

Hellman and others who concerned themselves with the study of growth and development largely depended upon skeletal remains. While this was a forward step, it did not bring with it the dynamic implications which emerged from Broadbent's roentgenographic cephalometric studies on living children. It was Broadbent's contributions which fired the imagination of workers in the field of roentgenographic cephalometrics. Researchers now began to employ this tool for longitudinal growth studies on the same living children as well as for cross-sectional research on different groups.

What started out as a semantic tool for research workers and as a descriptive method for teachers of growth and development was soon adopted by clinical orthodontists in their practice, with complete disregard for the apparent contradictions evidenced by the different analyses.

Practicing orthodontists accepted the findings of the cephalometrists at face value and are today employing the "standards" of the various analyses with definitive finality in establishing diagnosis and treatment planning. However, the cephalometrists themselves are far from being in agreement with one another. They have repeatedly cautioned orthodontists against basing individual case analysis, prognosis, and treatment planning solely on any special system of roentgenographic cephalometrics.

In an editorial* published in the JOURNAL, we called attention to the existing confusion and to the need for an objective reappraisal of roentgenographic cephalometrics, lest the swing of the pendulum set back this valuable aid in orthodontic research and therapy for years to come. We asked that the American Association of Orthodontists sponsor a workshop. With acute awareness of the interests of its members, the Association voted that a workshop be held.

Since the workshop was without precedent, and the ground had to be explored, as it were, it was thought best by the Workshop Committee to limit the number of participants. Although the Committee recognized that there were many men in the Association equally as qualified, participation was limited to the following: Allan G. Brodie, L. Bodine Higley, W. M. Krogman, William B. Downs, T. D. Graber, Robert G. Moyers, H. I. Margolis, B. Holly Broadbent, Professor Normand Hoerr (who succeeded the late T. Wingate Todd at Western Reserve University), C. Wesley Dupertuis (a leading physical anthropologist), and William H. Golden (in charge of roentgenology at the Bolton Headquarters), with J. A. Salzmann as chairman.

The stated purpose of the workshop was to try to find common areas of agreement with regard to (1) sites of craniofacial growth; (2) landmarks; (3) points of reference; (4) methods of locating the foregoing; (5) points, planes, and angles of measurement; (6) the significance of the various measurements obtained in the interpretation of growth and development changes, and (7) the validity of the norms thus obtained.

How well the workshop succeeded in accomplishing these aims can be learned from the transcript of the workshop when it is made available. Suffice it to say at this time that, while the workshop adopted certain points, angles, and planes, discussed minimum requirements, and evaluated other findings which should prove of value to the practicing orthodontist, there was practically no unanimity of opinion on most of the topics covered or on their degree of usefulness to the clinical orthodontist. This can be said of such an old standby as *porion,* as well as of most of the constellation of landmarks commonly used in roentgenographic cephalometrics.

Such unanimity of opinion as did result refers to the fact that roentgenographic cephalometrics requires a continuing clearinghouse for the evaluation of data obtained thus far and to the need for continuing research projects to define most of the points, angles, planes, and norms now accepted and widely used by practicing orthodontists. The Special Committee on Cephalometrics will make detailed recommendations to the American Association of Orthodontists relative to holding future workshops with wider participation by more workers in the field and by institutions where research on roentgenographic cephalometrics is currently in progress.

The workshop gave serious discussion and study of the masterful syllabus by Krogman and Sassouni.** The syllabus evaluates forty-five roentgeno-

*Salzmann, J. A.: Cephalometrics, Cephalometrists, and Orthodontics, Am. J. Orthodontics **41**: 709-711, 1955.

**Krogman, W. M., and Sassouni, V.: A Syllabus in Roentgenographic Cephalometry, Philadelphia Center for Research in Child Growth, 1701½ Fitzwater St., Philadelphia, Pennsylvania.

graphic cephalometric analyses and concludes with the warning: "Great caution should be exercised in the use, interpretation, and application of these tabulated norms."

The workshop had the advantage of the knowledge and experience of all the participants, among whom are to be found some of the foremost contributors in the field. Nevertheless, the value of the workshop lies as much in the fact that it points out how vastly greater the area of the unknown in roentgenographic cephalometrics is than the area of the known. There is at present more prevailing doubt than existing certainty in roentgenographic cephalometrics.

J. A. S.

Plan Now to Attend
1958 Meeting

American Association of Orthodontists

Commodore Hotel, New York City
April 27–May 1, 1958

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Reservations for rooms should be sent directly to the Commodore Hotel, New York City. A full program of entertainment for the ladies has been prepared. New York is waiting for you.

In Memoriam

JOSEPH O. BAKER
1896-1956

JOSEPH O. BAKER of St. Paul, Minnesota, died of leukemia on Wednesday, Oct. 31, 1956. Dr. Baker was born in La Crosse, Wisconsin, on Dec. 31, 1896. His preliminary education began in the La Crosse Public School and was followed by two years at the La Crosse Teacher's College. He became interested in dentistry while serving in the Army Medical Corps during World War I. After his discharge he enrolled in the University of Minnesota School of Dentistry and graduated in 1922. Dr. Baker began practicing dentistry in St. Paul and immediately became interested in orthodontics to a degree qualifying him to teach the subject at the University of Minnesota from 1928 to 1947, although he did not limit his practice to the specialty until 1935.

He was a member of local, state, and national dental societies, including the American Association of Orthodontics and the Central Section of the A.A.O. He held a certificate from the American Board of Orthodontists. He belonged to many organizations and clubs, but his chief avocation was the outdoors. He loved to hunt and fish, and his many friends in the north country were among those he valued most. He is survived by his wife, Frances; his daughter, Beverly (Mrs. James Deatherage of Phoenix, Arizona); a son Robert, who had the good fortune to be his associate for ten years; a twin brother, James, of St. Paul; and four grandchildren.

We of the orthodontic profession have lost a valuable member. The Central Section of the American Association of Orthodontists extends sincere sympathy to his family. May this resolution be included in our records and copies sent to his widow and immediate family.

Respectfully submitted,

H. B. Singler, D.D.S.
Arlo M. Dunn, D.D.S.
Leonard P. Wahl, D.D.S., Chairman
Necrology Committee

ASA J. LA GROW
1890-1956

ASA J. LA GROW, aged 66, of Oak Park, Illinois, died on Friday, Nov. 30, 1956, at the West Suburban Hospital following an illness of two months.

Dr. LaGrow, son of the late O. S. and Charity Wing LaGrow, was born on May 12, 1890, and had lived in Oak Park since he was 2 years of age. His

preparatory education was attained at the Whittier Graded School and Oak Park High School, after which he attended the Northwestern University Dental School where he graduated with a degree of dentistry in 1914. After serving as a captain in the Army Dental Corps in France from 1917 to 1919, he attended the Dewey School of Orthodontics in New York City. He returned the same year to open offices as an orthodontist in the Marion and North Boulevard Building; prior to this his offices were at Rigeland and Lake Streets. At the time of his death his offices were at 715 Lake St. in Oak Park.

Because of his indefatigable ambition to keep abreast in the specialty, when practice was rudimentary and experimental, he was referred to by his associates as the "dean of orthodontists."

He was a member of the Chicago Dental Society, the Illinois State Dental Society (life member), the American Dental Association, the Chicago Association of Orthodontists (past president and charter member), the West Suburban Orthodontists Association, the Central Section of the American Association of Orthodontists, the Chicago Chapter of Delta Sigma Delta Fraternity, the Rotary Club of Oak Park, Oak Park Masonic Lodge 540, American Legion (Oak Park Post 15), and the High Twelve Club. He was a former member of the Oak Park and Glen Oaks Country Clubs.

Additional avocations were gardening and the study of tree culture.

In the passing of Dr. LaGrow our specialty has lost a valuable member. His death was a severe shock to his many friends, who extend sincere sympathy.

Surviving are his widow, Helen Forbes LaGrow; a son, Asa J. LaGrow, Jr., of Mobile, Alabama; and a brother, Wing R. LaGrow of Glendale, California. May this resolution be included in our records and copies dispatched to his widow and immediate family.

Respectfully submitted,

H. B. Singler, D.D.S.
Arlo M. Dunn, D.D.S.
Leonard P. Wahl, D.D.S., Chairman
Necrology Committee

ARTHUR BARTLETT THOMPSON
1883-1957

ARTHUR BARTLETT THOMPSON of Des Moines, Iowa, died on Wednesday, Feb. 20, 1957, at the age of 73. He had practiced orthodontics exclusively since 1919 and retired because of illness two months prior to his death.

Dr. Thompson was born in Wall Lake, Iowa, on Sept. 14, 1883. He moved with his parents to Galesburg, Illinois, where he graduated from high school in 1901. He graduated from the Keokuk Dental College of Keokuk, Iowa, in 1905. He attended the Dewey School of Orthodontics in 1919 and

practiced the specialty exclusively until his retirement. Dr. Thompson was a distinguished student of dentistry and taught at the Keokuk Dental College a year after his graduation. He moved with the school to Des Moines when it was taken over by Drake University in 1908. He assisted in supervising the dental school at Drake University until 1913 when it was transferred to the University of Iowa. Dr. Thompson then entered private practice in Des Moines.

Dr. Thompson was a member of the Central Section of the American Association of Orthodontists, the American Association of Orthodontists, and other local, state, and national dental organizations. He was affiliated with the Congregational Church, Kiwanis Club, and Masonic bodies.

He is survived by his wife, Elizabeth, and a son, Clayton, of Tallahassee, Florida, to whom we extend our sincere sympathy, for we have lost a valuable member and friend.

BE IT RESOLVED that this tribute be made a part of the permanent record of the Central Section of the American Association of Orthodontists and that a copy be mailed to his wife and son.

Respectfully submitted,

H. B. Singler, D.D.S.
Arlo M. Dunn, D.D.S.
Leonard P. Wahl, D.D.S., Chairman
Necrology Committee

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Department of Orthodontic Abstracts and Reviews

Edited by

DR. J. A. SALZMANN, NEW YORK CITY

All communications concerning further information about abstracted material and the acceptance of articles or books for consideration in this department should be addressed to Dr. J. A. Sa'zmann, 654 Madison Avenue, New York City

Abstracts Presented Before the Research Section of the American Association of Orthodontists, New Orleans, May, 1957

Quantitative Electromyographic Analysis of Mastication: By Samuel Pruzansky, D.D.S., Department of Physical Medicine and Rehabilitation and the Cleft Palate Center, Chicago Professional Colleges, University of Illinois, Chicago, Illinois.

Efficiency is generally expressed as a ratio of the work or energy output to the energy input. Masticatory efficiency has been largely evaluated in terms of the work output. On the other hand, little knowledge is available concerning the energy input requirements during mastication of various foods. Such information would contribute toward a more complete evaluation of masticatory efficiency.

Since the electrical action current of a muscle is a measure of the force exerted by that muscle, a method for quantification of the electromyogram was sought. An improved integrating circuit capable of presenting energy data that may be correlated with actual muscle activity was found to provide the quantitative data required. The integrator consists of a capacitive integrating circuit and associated amplifiers, rectifiers, and control and power supply circuits designed by the Armour Research Foundation of the Illinois Institute of Technology. This equipment is designed for use with Offner electromyographic equipment. The record of energy levels presented on a crystograph recorder is correlated with other electromyographic data.

Each indication of the integrator records may be interpreted in terms of energy. Energy indicated is a function of the voltage across the condenser in the integration circuit. Since the energy is given in watt-seconds or watts multiplied by time, the measured muscle may then be classified either directly in terms of energy or in watts by multiplying by the number of integrator indications per second. The energy measured is that stored in the condenser and it can be referred back through the amplifiers to the electromyographic potentials. Comparison of muscle activity of various subjects by use of the indicator required standardization of the equipment prior to each study. A method of standardization that has been employed utilizes the electromyographic calibrator and an oscilloscope.

The Physiograph-Cephalostat: By V. Sassouni, D.F.M.P. (Paris), M.Sc. (Dent.), and W. M. Krogman, Ph.D., LL.D., Philadelphia Center for Research in Child Growth, Philadelphia, Pennsylvania.

The physiograph is a setup by means of which the head is oriented in the Frankfort horizontal without the need of a head holder. Its main advantage

lies in its simplicity and economy without sacrifice of accuracy. Most clinicians possess the equipment necessary for its use.

The Sassouni-Krogman physiograph consists of a standard slide projector (2 by 2 or 3 by 4). A slide representing a millimetric grid is projected on the face. One heavy horizontal line of the grid represents the FH; one heavy vertical line of the grid represents the midsagittal plane.

The patient is seated facing the projector; the head is then oriented so that the vertical line passes through nasion, and the horizontal line through left orbitale and right and left tragia. A headrest insures the immobility of the patient.

In this position, first a lateral x-ray picture is taken, and then a photograph called "physioprint" because of its special attributes. The physioprint, besides reproducing a scientifically accurate profile, also gives the size and proportions of the face in the three dimensions of space. If a frontal x-ray film is desired, the head is rotated 90 degrees (always oriented in the FH).

Even if a physioprint is not taken for record, it is possible to read directly under the projected grid the dimensions and proportions for a quick evaluation of the facial balance.

The accuracy of this technique implies the following conditions:

1. The camera (and the x-ray tube) and the projector should be oriented at right angles to each other.
2. The cassette should be perpendicular to the central x-rays.
3. The camera (and the x-ray tube) and the projector should be on the same horizontal level.
4. Distortion and magnification are avoided if the camera is at least 5 feet from the subject and the projector is 8 to 10 feet from the subject. (A corner of any office should fulfill these requirements.)

This technique may be applied in orthodontics, prosthetics, oral and plastic surgery, anthropology, and criminology.

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News and Notes

Ladies Program at 1958 Meeting of American Association of Orthodontists

Commodore Hotel, New York, N. Y.
April 27–May 1, 1958

Sunday, April 27

10-5 Ladies Registration. Grand Ballroom Foyer.

A member of the Ladies Entertainment Committee will be at the registration desk in the Grand Ballroom Foyer to help in the completion of your plans or to make plans for the following days and evenings of the meeting.

A lady from the New York Convention and Visitor's Bureau will be present to help with tours and information regarding places to dine or shop and will advise as to attendance at radio or TV broadcasts.

6 Get-Acquainted Cocktail Party.

Monday, April 28

9-11:30 Ladies Registration. Grand Ballroom Foyer.

Ladies are invited to attend all scientific sessions (admission by badge). During Monday morning's session (see program for time), a wonderful treat is in store for the members and their ladies when the renowned Rev. Dr. Norman Vincent Peale speaks and when Prof. James Neal discusses the much publicized subject of "X-ray Radiation and Genetics."

12:30 Luncheon and Fashion Show.

The beautiful Empire Room of the Waldorf-Astoria will be the scene of a delicious luncheon and a wonderful fashion show to be given by Miss Fontayne, designer, of New York. She will show her exclusive collection of late spring and summer fashions, completely accessorized. There will be favors, music, and two exciting door prizes, each for two seats for "My Fair Lady" for Monday evening.

Cocktails before luncheon will be available at the tables or in the famed Peacock Lounge near the main lobby.
Attendance limited—tickets necessary.

Tuesday, April 29

10:30-1 Ladies Registration. Grand Ballroom Foyer.

9-11 Complimentary Continental Breakfast in the East Ballroom. Attendance limited —tickets necessary.

As everyone coming to New York has a particular interest in something special, the balance of the day has been left open for your own plans. The members of the committee at the registration desk and the representative of the New York Convention and Visitor's Bureau will help you complete your plans and will aid in advising the proper agency to contact for tours, sight-seeing, or shopping. Some suggestions are: a trip to the nearby United Nations, visits to museums, the Planetarium, a trip around Manhattan by boat or by sight-seeing bus. These can be arranged upon your arrival in New York. Information about TV and radio broadcasts, shops, and restaurants, will also be available.

Wednesday, April 30

9-1 Ladies Registration. Grand Ballroom Foyer.

It is suggested that you plan this day for luncheons, matinees, or movies.

IMPORTANT! Tickets for theaters must be arranged for far in advance through your own theater ticket agency, the theater box office, or Tyson and Sullivan Theatre Ticket Service whose questionnaire you have received. Your reserved tickets may be picked up at their branch office in the Commodore Hotel.

6:30 President's Reception.

We shall be the guests of the Northeastern Society of Orthodontists for cocktails.

Banquet and dance in the Grand Ballroom. Songs by the internationally famous Yale University "Whiffenpoofs." Dancing to the music of Tony Cabot and his Victor Recording Orchestra.

Ladies Entertainment Committee

Dr. Norman L. Hillyer, Chairman — Mrs. Norman L. Hillyer, Co-Chairman

Executive Committee:

Mrs. Herbert H. Ernst
Mrs. Wilbur J. Prezzano
Mrs. Franklin A. Squires
Mrs. Donald B. Waugh

Committee:

Dr. Josephine M. Abelson
Mrs. Philip E. Adams
Mrs. George M. Anderson
Mrs. Ernest N. Bach
Mrs. Robert M. Bailey
Mrs. Henry C. Beebe
Mrs. Alfred J. Braida
Mrs. Horace P. Clark
Mrs. C. Sterling Conover
Mrs. John J. Dolce
Mrs. Stanley M. Dow
Mrs. Clifford G. Glaser
Mrs. Irving Grenadier
Mrs. Ashley E. Howes
Mrs. Donald Hutchinson
Mrs. William R. Joule
Mrs. Richard A. Lowy
Mrs. C. Edward Martinek
Mrs. David Mossberg
Mrs. Walter H. Mosmann
Mrs. Edward G. Murphy
Mrs. Donald D. Osborn
Mrs. Lowrie J. Porter
Mrs. J. A. Salzmann
Mrs. Earl E. Shepard
Mrs. George H. Siersma
Mrs. Henry Spiller
Mrs. Brainerd F. Swain
Mrs. John R. Thompson
Mrs. Everett A. Tisdale
Mrs. Leuman M. Waugh
Mrs. Faustin H. Weber
Mrs. Raymond L. Webster

American Association of Orthodontists
Registration of Nonmembers for Attendance at Annual Session

To insure full participation of all active members of the American Association of Orthodontists, the following classification of nonmembers eligible to attend and schedule of attendance fees, which will be charged at the time of registration, has been set up for the coming annual session of the Association at the Commodore Hotel, New York City, April 27 to May 1, 1958.

A. *No Attendance Fee.*

1. Full-time teachers in university dental schools.

2. Full-time graduate or postgraduate students in university orthodontic departments. It will be necessary to present a letter from the dean of the school certifying the status of the student.
3. Dentists from outside Canada or the United States of America who are members of recognized dental or orthodontic organizations.

B. *Attendance Fee—$10.00.*

1. Associate or junior members of constituent societies of the American Association of Orthodontists.
2. Recent graduates of university orthodontic departments who are in Government Service.

The Commodore Hotel in New York City, where the American Association of Orthodontists will hold its annual meeting April 27 to May 1, 1958. Reservations should be made early.

C. *Attendance Fee—$20.00.*

1. Recent graduates of university orthodontic departments who are not members of constituent societies of the American Association of Orthodontists.
2. Other guests.

Those persons who would be classified under the heading of C-1 or C-2 above are requested to apply to the chairman of the Credentials Committee at least sixty days before

the session for proper forms, which will require (a) written endorsement by two active members of the A. A. O. in the applicant's vicinity, (b) that the applicant be a member in good standing of the American Dental Association, and (c) that the applicant never have been rejected for membership in any of the constituent societies of the A. A. O.

Those persons who would be classified under the headings of A or B would be required only to submit credentials identifying themselves as being in one of these categories at the time of registration. Advanced reservations, which are by far most desirable, can be applied for by clearing one's credentials with the Credentials Committee by March 1, 1958.

Registration under categories C-1 and C-2 will, of necessity, be limited.

C. Sterling Conover
Chairman of the Credentials Committee
1 East 57th St.
New York, New York

American Association of Orthodontists 1958 Annual Meeting

In the great city of New York, the American Association of Orthodontists will hold its annual meeting, April 27 to May 1, 1958, at the Commodore Hotel.

Channel Gardens in spring. The Channel area of Rockefeller Center is 60 feet wide and 200 feet long. Six shallow pools of water are bordered by a constantly changing floral display. Bronze fountainheads, designed by Rene P. Chambellan, representing tritons and nereids feed the water into the pools. (Courtesy New York Convention and Visitors Bureau.)

American Association of Orthodontists Postconvention Cruise

Arrangements have been made for a delightful eight-day cruise on the "Ocean Monarch" of the Furness Lines to follow the annual meeting in New York City.

All arrangements are in the hands of Dr. C. W. Carrick of Oberlin, Ohio, owner of the Carrick Travel Bureau of that city. Dr. Carrick is the official travel consultant for the U. S. A. Section of Fédération Dentaire Internationale and has taken or sent hundreds of American dentists to these meetings over a period of thirty years.

On investigation, it has been found that this cruise and the ship to be used are ideal. Both Bermuda and Nassau, which will be visited, will be at the peak of their glory, and a marvelous experience will be in store for those who may make this trip.

For information write Dr. Carrick at the earliest possible moment.

Washington Arch. This monument, dedicated to the memory of the first President of the United States, was built in 1895 at a cost of $128,000.00. It stands 86 feet high and was designed by Stanford White. The arch span is 30 feet wide. (Courtesy New York Convention and Visitors Bureau.)

Scientific Program for the Fifty-fourth Annual Meeting of the American Association of Orthodontists, April 27 to May 1, 1958, Commodore Hotel, New York City

Sunday, April 27

10 A.M. to 5 P.M. Registration. Main Ballroom Foyer.

Monday, April 28

Opening Session

9:30 A.M.

Official opening of the meeting. President Squires.

Invocation. Dr. Arthur Stanley Wheelock, Church of the Highlands, White Plains, New York.

Address of Welcome. Percy T. Phillips, President-Elect of the American Dental Association.

Response. C. Edward Martinek, President-Elect of the American Association of Orthodontists.

President's Address. Franklin A. Squires.

Scientific Session

(Presiding—John R. Thompson, Program Committee Chairman)

10:30 A.M.

The Responsibility of the Professional Person to His Patients, Society, and Himself. Dr. Norman Vincent Peale, Minister, Marble Collegiate Church, New York City.

11:15 A.M.

Radiation and Genetics. James V. Neel, Professor of Human Genetics and Chairman of the Department, University of Michigan Medical School.

12:15 P.M.

Golden Anniversary Luncheon.

2 P.M.

Presentation of the Albert H. Ketcham Memorial Award of the American Board of Orthodontics. Presentation by Lowrie J. Porter, President, The American Board of Orthodontics. Acceptance by Joseph Davis Eby and H. Carlyle Pollock, Sr.

Scientific Session

(Presiding Chairman—Clifford G. Glaser, President,
Northeastern Society of Orthodontists)

SYMPOSIUM ON SERIAL EXTRACTION PROCEDURES

(The purpose of this symposium is to bring together the points of view of a number of outstanding exponents of this important but controversial subject.)

2:30 P.M.

Introduction: Current Concepts on Serial Extraction in Orthodontic Treatment. B. F. Dewel, Evanston, Illinois.

3:15 P.M.

Collaboration:

1. Serial Extraction as a Treatment Procedure. Z. Bernard Lloyd, Washington, D. C.
2. Research Studies on Serial Extraction. Kenneth C. Marshall, St. Louis, Missouri.
3. Why Serial Extraction? Warren R. Mayne, Salem, Massachusetts.

4:45 P.M.

The Treatment of Anterior Open Bite Malocclusion Associated With Unfavorable Facial Skeletal Pattern. J. William Adams, Indianapolis, Indiana.

Tuesday, April 29

Scientific Session

(Presiding Chairman—George H. Siersma, Vice-President, American Association of Orthodontists)

DISCUSSION SYMPOSIUM

(The purpose of this symposium is to bring together the opinions of scientists and clinical orthodontists on a current, controversial subject in orthodontics.)

9 A.M.

Introduction of the Subject:

The Lower Incisor—Its Influence on Treatment and Esthetics.
John T. Lindquist, Indianapolis, Indiana.
(This paper, an American Board thesis for 1957, was published in the February issue of the AMERICAN JOURNAL OF ORTHODONTICS so that the audience would have the opportunity to study it in advance of the meeting.)

Discussion of the Subject:

1. From the Viewpoint of Anthropology.
   Wilton M. Krogman, Ph.D., Professor of Physical Anthropology, University of Pennsylvania, Director of The Philadelphia Center for Research in Child Growth, Philadelphia, Pennsylvania.
2. From the Viewpoint of Growth.
   Harry Sicher, M.D., Professor of Anatomy, Chicago College of Dental Surgery, Loyola University, Chicago, Illinois.
3. From the Viewpoint of Orthodontics.
   Wendell L. Wylie, Professor of Orthodontics, University of California and practitioner of Orthodontics, San Francisco, California; Secretary, American Board of Orthodontics.

10:45 A.M.

Milo Hellman Research Award. Reading of the Prize Winning Essay and presentation of the award by President Squires.

11:30 A.M.

First Business Meeting.

12:30 P.M.

Past-President's Luncheon.

Research Section

(Presiding Chairman—J. William Adams)

1:30 P.M.

Research Reports. A supplement to this program, issued at the time of registration, will contain the details of this phase of the program. Each report will be limited to 10 minutes.

Wednesday, April 30

9 A.M.

Table Clinic Session. William R. Joule, Chairman.

12 M.

Round-Table Discussion Luncheon. Horace P. Clark, Chairman.

Subjects:

1. Serial Extraction Therapy
2. Extraoral Therapy
3. Relapse Cases

4. Cephalometric Radiography
5. General Discussion

2 P.M.

First Appliance Therapy Panel Session
and
First Limited Attendance Clinic Session.

3:30 P.M.

Second Appliance Therapy Panel Session
and
Second Limited Attendance Clinic Session.

Appliance Therapy Questions:

1. How do you move maxillary canines distally in first bicuspid extraction cases?
2. How do you reinforce maxillary anchorage in the retraction of maxillary canines?
3. How do you maintain anchorage in the mandibular arch while exerting traction posteriorly on maxillary teeth?
4. How do you move teeth vertically to establish desired occlusal levels in deep or excessive overbite cases?

Panelists:

2 P.M.

Group 1 (Presiding Chairman—Richard A. Lowy).

1. Paul D. Lewis, Seattle, Washington.
2. Harry L. Bull, Jersey City, New Jersey.
3. Ralph E. Braden, Memphis, Tennessee.
4. G. Vernon Fisk, Toronto, Canada.

3:30 P.M.

Group 2 (Presiding Chairman—Ernest L. Johnson).

1. Joseph R. Jarabak, Chicago, Illinois.
2. H. K. Terry, Miami, Florida.
3. Howard Yost, Grand Island, Nebraska.
4. William L. Wilson, Boston, Massachusetts.

Thursday, May 1

Scientific Session

(Presiding—Joseph D. Eby, Past-President, American Association of Orthodontists)

9 A.M.

Re-evaluating Our Relapses.
Robert R. McGonagle, Euclid, Ohio.

9:45 A.M.

Symposium on Extraoral Therapy.

Introduction:

A Present-Day Evaluation of the Analysis and Therapy of the Extraoral Anchorage Application in the Treatment of Class II Malocclusions.
Silas J. Kloehn, Appleton, Wisconsin.

Collaboration:

Total Extraoral Therapy.
James Jay, New York, New York.
The Use of Extraoral Anchorage as a Clinical Aid to Reduce or Avoid the

Need for Intermaxillary Elastic Traction.
Waldo O. Urban, Evanston, Illinois.

11:30 A.M.

Report on the Roentgenographic Cephalometric Workshop.
Résumé of the Workshop and Limitations of the Technic.
J. A. Salzmann, New York, New York.
Requisites and Criteria of the Technic.
T. M. Graber, Chicago, Illinois.
Validation of the Technic.
Wilton M. Krogman, Philadelphia, Pennsylvania.

12:15 P.M.

Second Business Meeting.
Installation of Officers.
Presentation of the Past-President's Key to
Franklin A. Squires by A. C. Broussard.

Northeastern Society of Orthodontists

The Northeastern Society of Orthodontists will hold its annual business meeting at the Commodore Hotel in New York City on Tuesday, April 29, 1958. There will be no scientific meeting of the Society, since the American Association of Orthodontists will be meeting in New York at that time.

University of North Carolina School of Dentistry

The Department of Orthodontics announces a postgraduate course in "The Labio-Lingual Technic for Orthodontists," to be given July 27 through August 1, 1958.

This six-day course will be composed of lectures on fundamental orthodontic problems and laboratory assignments in construction of appliances, including the occlusal guide plane. In addition to practical demonstrations of these principles, students will be required to construct appliances for cases from their own practices. Scientific presentations in closely allied fields will supplement the technical aspects of the course.

Faculty: The course will be under the direction of Oren A. Oliver, D.D.S., L.L.D., Nashville, Tennessee, assisted by Boyd W. Tarpley, B.A., D.D.S., Miami, Florida; Harold K. Terry, B.S., D.M.D., Birmingham, Alabama; and William H. Oliver, D.M.D., Nashville, Tennessee.

Admission to the course: Admission is limited to persons in the exclusive practice or teaching of orthodontics.

For further information, write to Director of Postgraduate Dental Education, School of Dentistry, Box #750, Chapel Hill, North Carolina.

U. S. Department of Health, Education, and Welfare

The Public Health Service has announced that it is accepting applications from professional health workers for graduate training in public health for the 1958-1959 academic year.

This program was set up by Congress two years ago to help relieve the shortage of trained personnel in public health agencies.

In the President's budget, submitted Jan. 13, 1958, $2 million is requested for the program in fiscal year 1958-1959 to give additional training to physicians, nurses, sanitary engineers, and other professional personnel whose skills are required in modern public health practice and who are interested in making this field their career.

Congress voted $1 million for the first year of the program in 1956-1957 and $2 million for the second year. A total of 895 traineeships has been awarded to individuals either directly by the Public Health Service or through grants to public health training institutions.

Awards totalled 363 during the first year, and 532 have been granted so far during the fiscal year 1957-1958. These include 67 physicians, 462 nurses, 94 health educators, 65 sanitarians, 61 sanitary engineers, 29 laboratory workers, 28 dentists, 23 veterinarians, and 17 nutritionists.

In addition to tuition and fees, the traineeships provide stipends covering the living expenses of the trainees and their legal dependents. Applications should be submitted by March 1, 1958.

Additional information is available from the following offices of the U. S. Department of Health, Education, and Welfare:

Division of General Health Services
Public Health Service
Washington 25, D. C.

Regional Director
DHEW
42 Broadway
New York 4, New York

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700 East Jefferson St.
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American Association for Cleft Palate Rehabilitation

The American Association for Cleft Palate Rehabilitation will hold its sixteenth annual convention at the St. Francis Hotel in San Francisco, California, on Thursday, Friday, and Saturday, April 24 to 26, 1958.

Notes of Interest

Dr. Eleanor Mary Hallman announces the association of Dr. Harry W. Hallman in the exclusive practice of orthodontics at 32 North Queen St., York, Pennsylvania.

Harry E. Jerrold, D.D.S., and Theodore L. Jerrold, D.D.S., 359 New York Ave., Brooklyn, New York, announce the association of Philip Jaffe, D.D.S., in the practice of orthodontics.

Drs. Edward C. King and Robert W. Baker take pleasure in announcing that Dr. Richard P. Udall is now associated with them in the practice of orthodontics, 400-403 Seneca Bldg., Ithaca, New York, and Dental Arts Bldg., Cortland, New York.

William Silverman, D.D.S., announces the opening of his office at 14 Rawley Pl., Millburn, New Jersey, practice limited to orthodontics.

R. James Vassar, D.D.S., M.S.D., announces the opening of his office at 36 North Duke St., York, Pennsylvania, practice limited to orthodontics.

OFFICERS OF ORTHODONTIC SOCIETIES

The AMERICAN JOURNAL OF ORTHODONTICS is the official publication of the American Association of Orthodontists and its component societies. The Editorial Board of the JOURNAL is composed of a representative of each of the component societies.

American Association of Orthodontists
(Next meeting April 27–May 1, 1958, New York)

President, Franklin A. Squires – – – – – – – – Medical Centre, White Plains, N. Y.
President-Elect, Edward C. Martinek – – – – – – – – – Fisher Bldg., Detroit, Mich.
Vice-President, George H. Siersma – – – – – – – – – Republic Bldg., Denver, Colo.
Secretary-Treasurer, Earl E. Shepard – – – – – – – – 8230 Forsyth, St. Louis, Mo

Central Section of the American Association of Orthodontists
(Next meeting Sept. 29-30, 1958, Cedar Rapids)

President, Frederick B. Lehman – 1107 Merchants National Bank Bldg., Cedar Rapids, Iowa
Secretary-Treasurer, William F. Ford – – – – – – – 575 Lincoln Ave., Winnetka, Ill.
Director, Elmer F. Bay – – – – – – – – – – 216 Medical Arts Bldg., Omaha, Neb.

Great Lakes Society of Orthodontists
(Next meeting Nov. 2-5, 1958, Pittsburgh)

President, Edwin G. Flint – – – – – – – – – 8047 Jenkins Arcade, Pittsburgh, Pa.
Treasurer, D. C. Miller – – – – – – – – – – – 40 South Third St., Columbus, Ohio
Director, Robert E. Wade – – – – – – – – – – – 327 E. State St., Columbus, Ohio

Middle Atlantic Society of Orthodontists
(Next meeting Oct. 12-14, 1958, Atlantic City)

President, Gerard A. Devlin – – – – – – – – – – 121 Prospect St., Westfield, N. J.
Secretary-Treasurer, Paul A. Deems – – – – – – – – – 835 Park Ave., Baltimore, Md.
Director, George M. Anderson – – – – – – – – 3700 North Charles St., Baltimore, Md.

Northeastern Society of Orthodontists
(Next meeting April 29, 1958, New York)

President, Clifford G. Glaser – – – – – – – – – 1255 Delaware Ave., Buffalo, N. Y.
Secretary-Treasurer, David Mossberg – – – – – – 36 Central Park S., New York, N. Y.
Director, Norman L. Hillyer – – – – – – – – 230 Hilton Ave., Hempstead, L. I., N. Y.

Pacific Coast Society of Orthodontists
(Next meeting Feb. 23-27, 1958, Santa Barbara)

President, A. Frank Heimlich – – – – – – – – 1824 State St., Santa Barbara, Calif.
Secretary-Treasurer, Raymond M. Curtner – – – – – 450 Sutter St., San Francisco, Calif.
Director, A. Frank Heimlich – – – – – – – – – 1824 State St., Santa Barbara, Calif.

Rocky Mountain Society of Orthodontists
(Next meeting Sept. 7-9, 1958, Moran, Wyo.)

President, George E. Ewan – – – – – – – – Bank of Commerce Bldg., Sheridan, Wyo.
Secretary-Treasurer, H. Carlyle Pollock, Jr. – – – – 915 South Colorado Blvd., Denver, Colo.
Director, Ernest T. Klein – – – – – – – – – – – Republic Bldg., Denver, Colo.

Southern Society of Orthodontists

President, John A. Atkinson – – – – – – – – – – 898 Starks Bldg., Louisville, Ky.
Secretary-Treasurer, H. K. Terry – – – – – – – – 2742 Biscayne Blvd., Miami, Fla.
Director, Edgar Baker – – – – – – – – – – – Professional Bldg., Raleigh, N. C.

Southwestern Society of Orthodontists
(Next meeting Oct. 5-8, 1958, Little Rock)

President, Thermon B. Smith – – – – – – – – – 1122 W. Capitol, Little Rock, Ark.
Secretary-Treasurer, Harold S. Born – – – – – – – 908 S. Johnstone, Bartlesville, Okla.
Director, Nathan Gaston – – – – – – – – – – – 701 Walnut St., Monroe, La.

American Board of Orthodontics

President, Lowrie J. Porter – – – – – – – – – – 41 East 57th St., New York, N. Y.
Vice-President, William R. Humphrey – – – – – – – – – Republic Bldg., Denver, Colo.
Secretary, Wendell L. Wylie – – – – – University of California School of Dentistry, The Medical Center, San Francisco, Calif.
Treasurer, Jacob A. Salzmann – – – – – – – – – 654 Madison Ave., New York, N. Y.
Director, L. Bodine Higley – – – – – University of North Carolina, Chapel Hill, N. C.
Director, B. F. Dewel – – – – – – – – – – – – 708 Church St., Evanston, Ill.
Director, Frank P. Bowyer – – – – – – – – 608 Medical Arts Bldg., Knoxville, Tenn.

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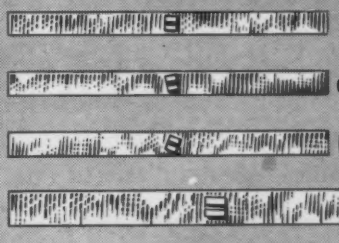

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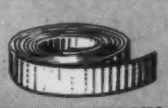

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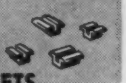

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As the Society aids the doctor, so does its large corps of volunteers aid the cancer patient with dressings, transportation, home care, medication and a host of other vitally needed services.

For the past two years, the theme of the Society's annual Crusade has been "Fight Cancer with a Checkup and a Check." That Americans everywhere are learning the value of the annual health checkup in the fight against cancer, is evidenced by the fact that doctors report they are now seeing more cancer in its earliest stages than ever before.

That American men and women have a personal stake in the program of the American Cancer Society is demonstrated by the public's generous support of the Crusade. This year the goal is $30,000,000 and we are confident that our people will meet the challenge . . . will "fight cancer with a checkup and a check" in the encouragement of further progress.

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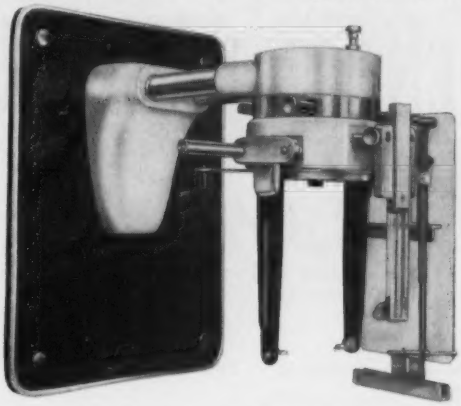

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by

LEONARD M. MONHEIM, B.S., M.S., D.D.S. Professor and Head of Department of Anesthesia, University of Pittsburgh School of Dentistry; Assistant Professor, Department of Surgery (Anesthesia), University of Pittsburgh School of Medicine.

1957, 299 pages, 5⅞″ x 9″, 128 illustrations. Price, $8.75.

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It is the author's sincere opinion that there is no procedure in dentistry which cannot be performed painlessly, if the dentist has the will to do so. To practice pain control successfully, the practitioner should have a thorough understanding of the nature of pain and how it comes about. In this book the author explains the neuroanatomy involved, the pharmacology of the local anesthetics, analgesics and associated drugs. Here for the first time the over-all control of pain is advocated in dental practice.

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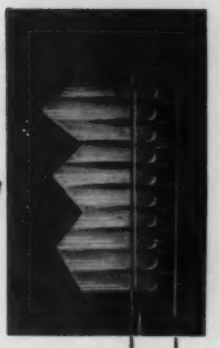

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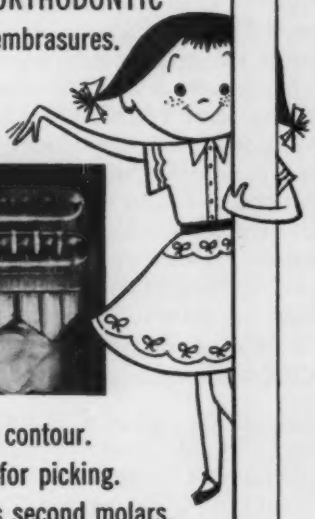

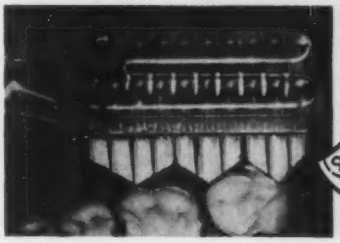

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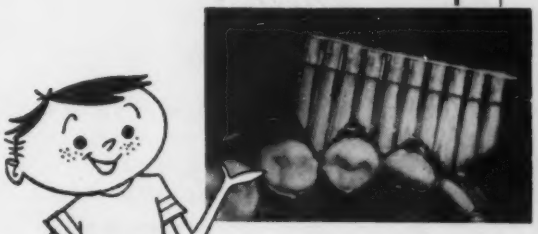

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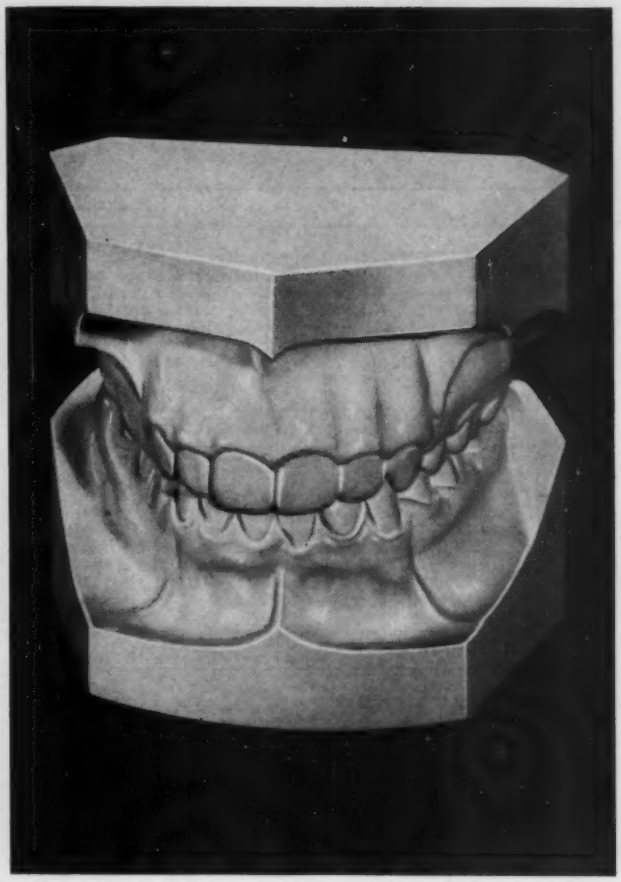

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Cettel Studios, The ---------- 27

Engelhard Industries, Inc., Baker Dental Division ---------- 1, 14

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Olympic Laboratories ---------- 27
Orthodontic Classified Advertisements 28
Orthodontic Specialties Laboratory -- 11

Rocky Mountain Metal Products -- 17, 18

Specialists Laboratory for Orthodontists ---------- 21
Stratford-Cookson Company -------- 29

Thrombley, Gilbert W. ---------- 7
Tufts University ---------- 28

United States Savings Bonds ------ 26
Unitek Corporation ---------- 8, 9

Wehmer X-Ray Specialties, B. F. ---- 21
White Dental Manufacturing Company, The S. S. ---------- Fourth Cover
Wilkinson Company, The ---------- 23
Williams Gold Refining Company, Inc. ---------- 12, 13
Williams Gold Refining Company, Inc. ---------- Second Cover
Williams & Wilkins Company -------- 15

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